WAR DEPARTMENT

TECHNICAL MANUAL

INSTRUMENT TRAINER MAINTENANCE

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INSTRUMENT TRAINER MAINTENANCE

SECTION I
GENERAL

1. General.—*a.* Experience has proved that the flying time necessary to become qualified on instruments can be reduced by more than 50 percent through proper use of the instrument flying trainer; also that more can be accomplished in the trainer in a given period of time than in an airplane.

b. In order that the maximum benefits for which the trainer was designed may be obtained it is imperative that it be properly maintained. A highly developed mechanism such as this cannot be expected to function properly without proper maintenance. If thorough maintenance is not accomplished at regular intervals, the trainer will not only lose its value as a means of improving instrument flying technique but may be the cause of the development of undesirable or even unsafe habits.

c. Maintenance of the trainer is neither difficult nor expensive if properly done. Any adjustments required from time to time may be quickly and easily accomplished if the maintenance man knows his trainer thoroughly.

d. Most difficult for the maintenance man to learn is what *not* to do. Many of the linkages and adjustments are so interconnected that an

adjustment improperly made or not made in its proper sequence may easily disrupt several other adjustments.

e. The maintenance man should observe two precautions at all times: study carefully the section of the manual dealing with the part in question to make sure he is about to do the right thing and then, before making the adjustment, mark it so he can put it back as it was in event he is wrong. *Know what you are doing.*

f. There is nothing mysterious about the mechanics of the trainer, as it employs principles that are in daily use. The application of these principles is, however, sufficiently different so that persons not thoroughly familiar with the trainer and all of its aspects should never attempt repairs or adjustments without first carefully studying this manual or consulting someone who knows.

g. The trainer consists of a fuselage with wings, empennage, and hood containing the controls and all of the flight instruments necessary for instrument flight. This fuselage is mounted on a universal joint in such a manner as to permit movement in bank or pitch in excess of maneuvers normally done on instruments. The universal joint is in turn mounted on a turntable known as the revolving octagon which is free to revolve indefinitely about the vertical axis. Movement about any of the three axes or combination thereof is controlled as in an airplane—by wheel or stick and rudder pedals, attached to valves which in turn control vacuum-operated bellows. Vacuum is supplied by a turbine driven by an electric motor located in the base of the trainer.

h. By partially evacuating the air from a tank, "altitude" is created. This altitude is governed by suitable valves through a differential linkage in such a manner that indications of altitude are the result of nose-up or nose-down attitude and throttle setting.

i. This differential spacing linkage also causes proper indications of air speed and engine speed while rate of change of altitude is shown by a vertical speed indicator. The directional gyro and turn and bank indicators are operated as in an airplane. Since centrifugal force is not present, the artificial horizon or flight indicator is pendulum-operated. Lacking centrifugal force to operate the bank indicator, the inclinometer is linked to the turn indicator.

j. Since the purpose of the trainer is to furnish a means whereby instrument flying may be taught or practiced, no concession has been made to "feel" except for the addition of slip-stream simulators which supply resistance to the controls thereby simulating the flow of the air stream over the control surfaces. In addition, no inherent stability has been built into the trainer; consequently the student is

required to "fly" the trainer at all times. Concurrent with the trainer's lack of stability is the rough air mechanism, controlled by the instructor, which serves as a method of creating bumps or simulating "stormy" conditions.

k. The complete trainer installation includes an instructor's desk which houses the electrical apparatus and controls for producing radio signals and two-way voice communication.

l. The means of tracing on a map or chart the course the student flies in the trainer is provided by the flight log or recorder which operates on the instructors desk.

m. Types C–4, C–3, and C–5 trainers are supplied with a remote indicating system of instruments at the instructor's desk which duplicate by means of repeater instruments the indications given by the trainer altimeter, vertical speed and air speed indicators.

n. C–3 and C–5 trainers are equipped with a wind drift mechanism which injects into a problem, as desired, any wind from 0 to 60 mph from any direction, with consequent gain or loss of ground speed as indicated by the track traced by the recorder. This equipment is also available for attachment to the C–4 type.

o. Since all trainer types are basically the same, no attempt has been made to write this manual around any one particular type, but rather in such a manner that all types in use in the Army Air Forces at this time will be covered. All parts and subassemblies that are not common to all types will be so labeled and explained.

p. The various trainer types now in use in the Army Air Forces were not manufactured and delivered as the numerical sequence of the various types would indicate. The C–2 type were the first received and put into use in any number. The C–2 was followed by the C–4 which the manufacturer designated as the Model E and Special E. A few of the Special E trainers were purchased and are in use at this time. However, all of this particular type are designated by the Army as C–4's.

q. The next type delivered on contract was the C–5, which differed from previous types mainly in that it was equipped with an automatic wind drift device and included actual radio equipment.

r. The latest type, the C–3, is being delivered in large quantities at this time and is essentially the same trainer as the C–5, except that the actual radio equipment has been replaced by a new type "radio simulator".

s. Section II deals solely with the location, nomenclature, and general function of the various parts and subassemblies, and has been divided into four main divisions: fuselage, revolving octagon, base,

and desk. Section III deals with the three principles of operation of the complete unit: vacuum, mechanical, and electrical. Description of the individual units and subassemblies and methods of regulating and adjusting those units and subassemblies is covered in section IV. Inspection and maintenance information relative to the complete unit is dealt with in section V, while section VI covers installation.

2. Axes of movement.—*a.* In order that the layman may fully understand the various attitude controls and maneuvers of an airplane, and how the various assemblies of the trainer operate and are affected by various trainer attitudes in simulating airplane instrument indications, it is necessary that he know what movements are possible, about what axes the movements take place, and the control or controls that cause the maneuver.

b. Following is an explanation of the three axes of movement of an airplane or trainer (fig. 1):

(1) The longitudinal (X) axis is a line running from the center of the nose through the center of gravity and out the tail, or a straight line through the center of gravity, fore and aft in the plane symmetry. In general theoretical discussions of the motion of an airplane, this may be taken as being parallel to the propeller axis of a single-engine tractor type airplane. In mathematical theory this is the "X" axis. Motion taking place about this axis is referred to as "roll" or "bank" controlled by the wheel or stick.

(2) The lateral (Y) axis is a horizontal line through the center of gravity, perpendicular to the longitudinal axis and running from wing tip to wing tip. In mathematical theory this axis is referred to as the "Y" axis. Motion taking place about this axis is referred to as pitch or pitching motion (climb or dive) controlled by the control column or stick.

(3) The vertical or normal axis is a line running through the center of gravity perpendicular to the other two axes. When the longitudinal and lateral axes are horizontal and the airplane is in the attitude of level flight, the normal axis is vertical. In mathematical theory this axis is the "Z" axis. Motion about this axis is called "yawing" or "turning" motion and is controlled primarily in an airplane by the rudder.

c. These axes must be considered as moving with the airplane and always remaining fixed relative to the airplane; that is, the lateral axis will remain parallel to the line joining the wing tips in whatever attitude the airplane may be or, during a vertical dive, the longitudinal axis will be vertical and the lateral and normal axis will be horizontal.

d. The axes of the trainer are the same, theoretically, as for an actual airplane. However, for practical reasons, these axes actually intersect in the center of the main universal joint that supports the trainer fuselage on the revolving octagon. The lateral axis extends through the pitching bearings and the longitudinal axis extends through the banking bearings of this assembly; the vertical axis runs perpendicularly through the gimbal ring.

e. For theoretical explanation of the trainer's movements, the axes may be considered as follows:

(1) *Longitudinal axis.*—A straight line extending from the center of the nose of the trainer through the length of the fuselage.

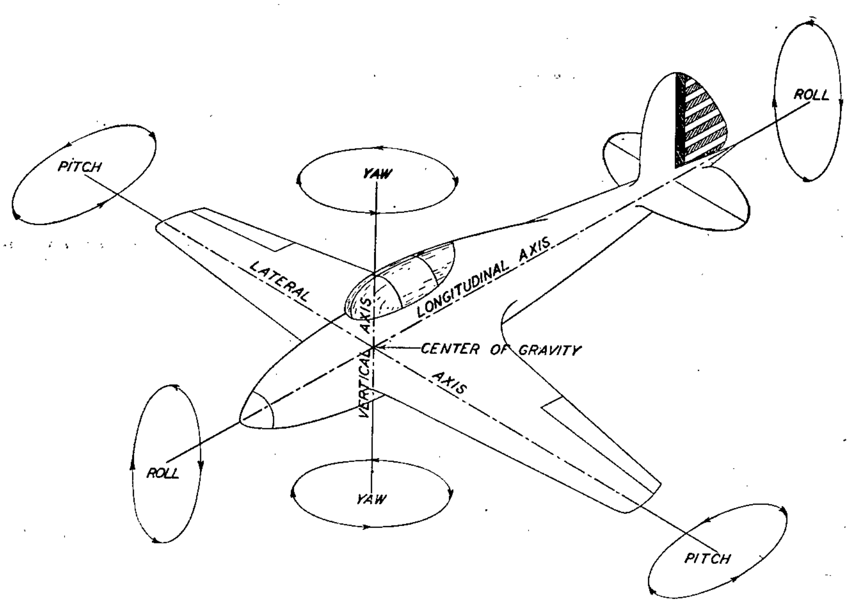


FIGURE 1.—Axes of movement.

(2) *Lateral axis.*—A straight line extending parallel to the center of the left fuselage hook-up bar to the center of the right stop bar midway of the fuselage.

(3) *Vertical or normal axis.*—A straight line at right angles to the longitudinal and lateral axes extending vertically through the center of the main air transfer column.

Section II

LOCATION, IDENTIFICATION, AND GENERAL FUNCTION OF COMPONENT PARTS

3. General.—*a.* The purpose of this section is to familiarize the student with the proper nomenclature, physical location, and the purpose of the various parts and subassemblies of the four main assemblies (fuselage, octagon, base, and desk) so that future explanations of the various interconnecting functions of these units may be more readily understood and retained.

b. Figures 2, 3, and 4, with their accompanying code, show graphically the location of the units included in the fuselage; figures 21 and 22, the octagon; figures 28 and 29, the base; and figures 35 and 36, the desk.

4. Fuselage.—The following units and subassemblies are located in the trainer fuselage:

a. Air transfer manifold.—(1) The air transfer manifold (fig. 5) consists of two parts, the manifold elbow and the main distributing manifold. The manifold elbow is constructed of 1½-inch metal tubing cut and welded to form an offset elbow extending from the top of the air transfer column to a point approximately 9 inches diagonally to the rear and right of the fuselage and approximately 3 inches off the fuselage floor. Here, by use of black drill-covered rubber hose and hose clamps, it is connected to the main distributing manifold which is constructed of 1⅛-inch metal tubing, and lies in the horizontal plane parallel to and approximately 4 inches behind the rudder bar.

(2) The manifold elbow has five outlets to which are connected the various instrument vacuum lines and the spin valve. These outlets vary in size from ⅛ inch to 5/16 inch. The main distributing manifold has four outlets, two of which are 9/16 inch in size and are used as vacuum connections to two of the main valves; one is 15/16 inch in size and used as a vacuum connection to the other main valve, and one is ⅛ inch in size and used as a vacuum connection to the stall valve.

b. Main control valves.—(1) Three main control valves are used. These valves are all similar in design and construction. There are

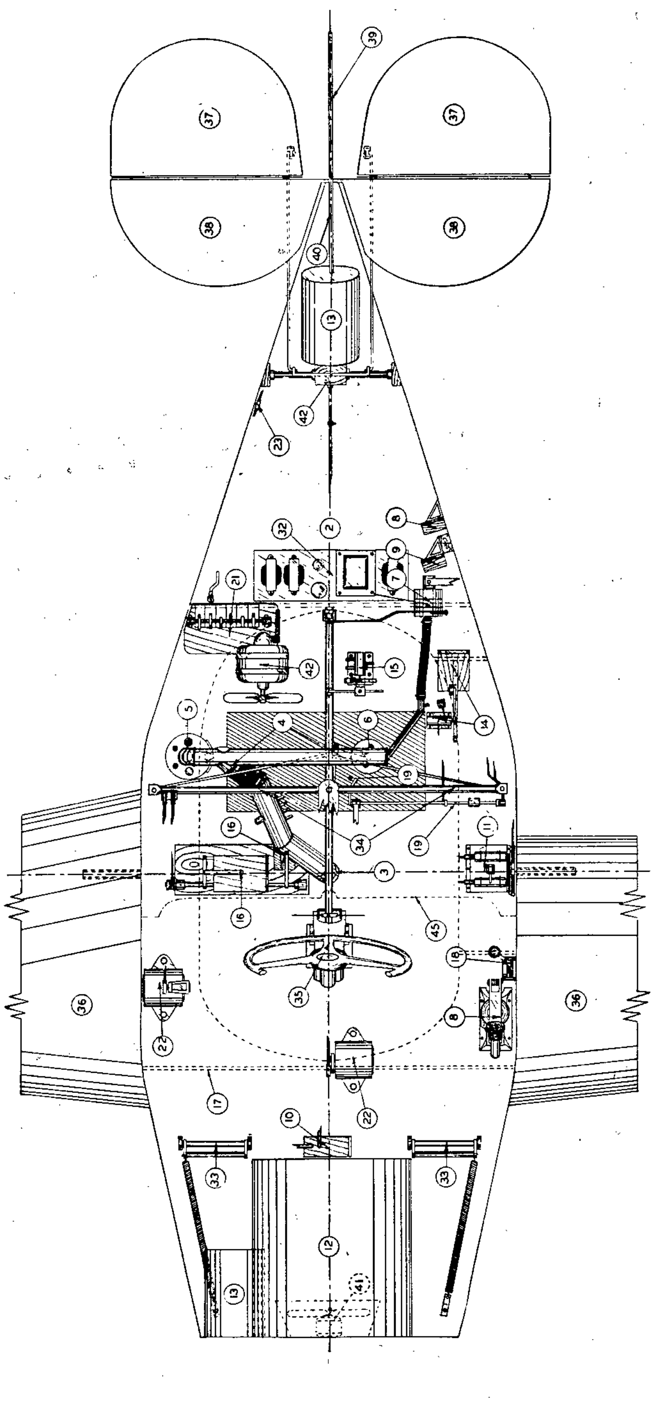


FIGURE 2.—Fuselage—top view.

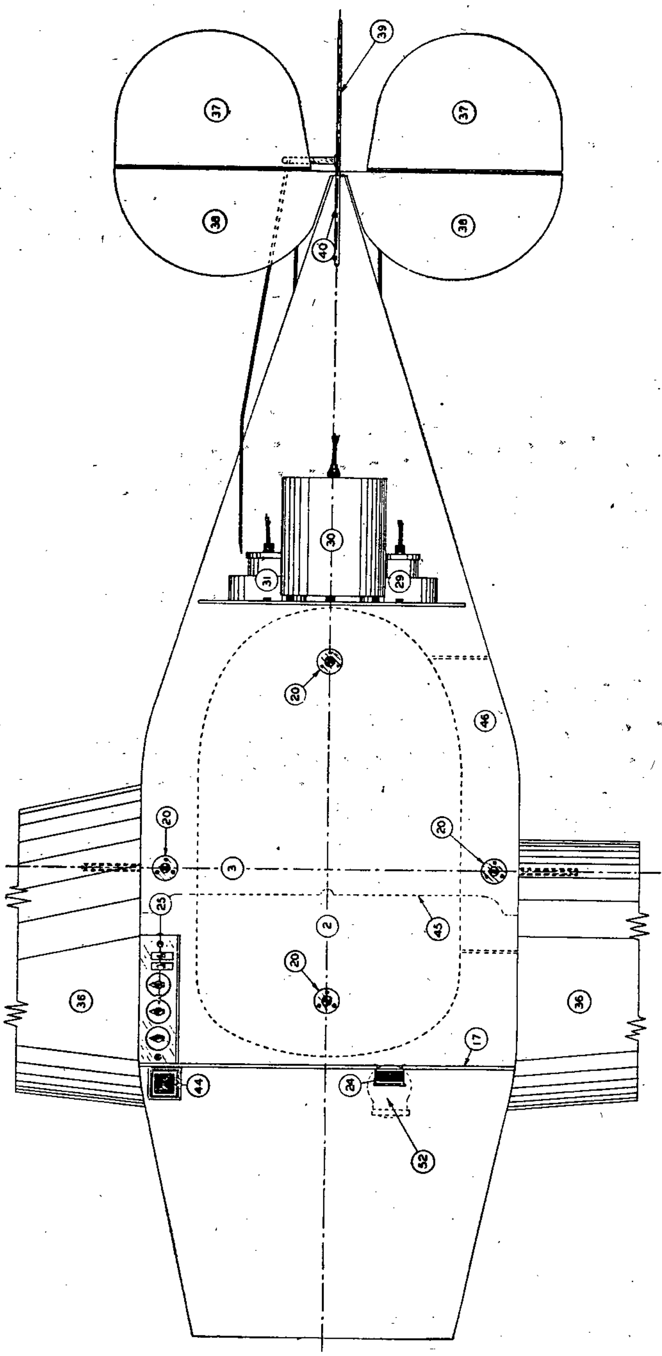


FIGURE 3.—Fuselage—top view.

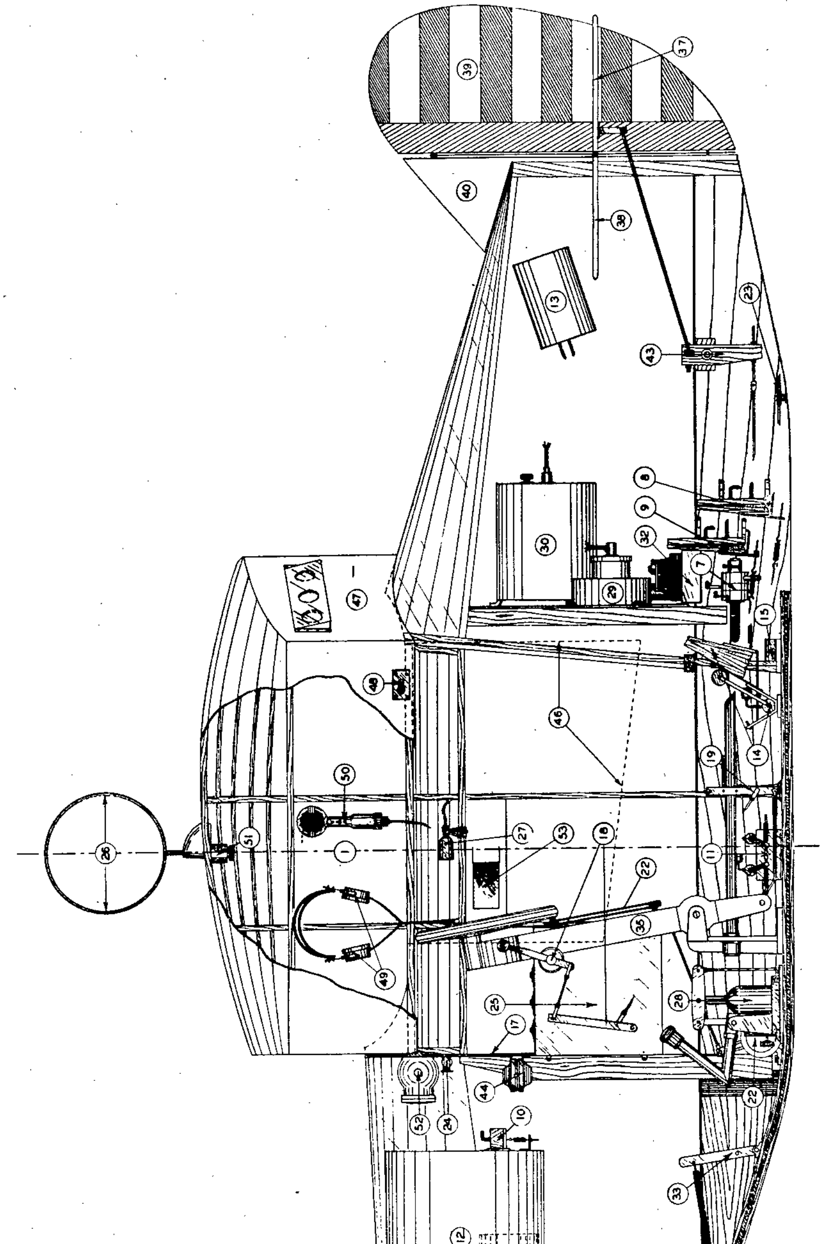


FIGURE 4.—Fuselage—side view.

slight differences built into two of the main valves to cause certain characteristics of control. These differences are covered thoroughly in section IV.

(2) The main control valves are constructed of two metal disks, each disk being approximately 1½ inches thick, and 3 inches in diameter. These disks, when in use, are mounted one on top of the other, and are referred to as the "top half" and the "bottom half". In every case, the bottom half of the valve is held in a fixed position by means of a bracket and setscrew; while the top half of the valve is free to move when the control to which it is connected is moved. Vacuum is applied to the top half of the valve through channels bored into the top half; vacuum is applied to the bottom half through channels bored into the lower half to the two outlets on the base of

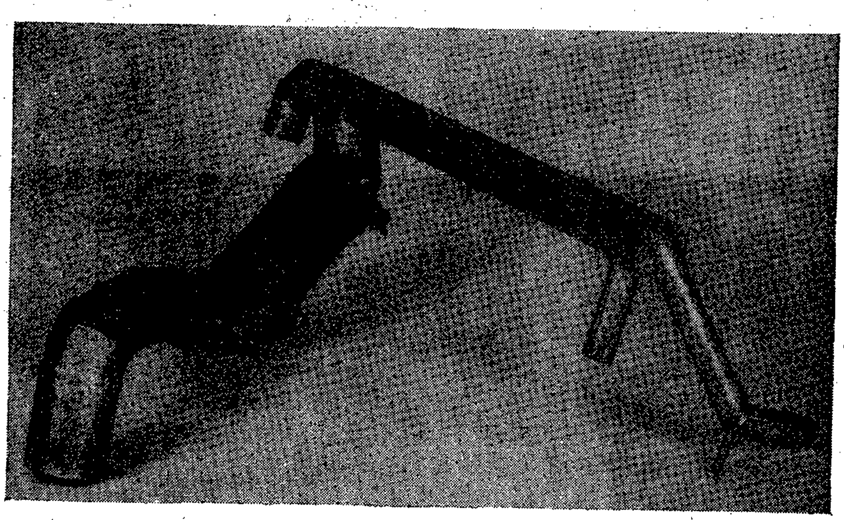


FIGURE 5.—Air transfer manifold.

the valve. By moving any one of the controls, the top half of the corresponding valve is caused to rotate, thereby controlling the application of vacuum through that valve.

(3) There are three main valves: the rudder valve (fig. 6); aileron valve (fig. 7); and elevator valve used to control movement of the trainer about its three axes.

(*a*) The rudder valve is located under the pilot's seat on the right-hand side of the fuselage, and is mounted in a vertical position. It is connected to and caused to operate by the rudder pedals. Movement of the trainer caused by the rudder valve is around the vertical axis and is called "yawing" or "turning".

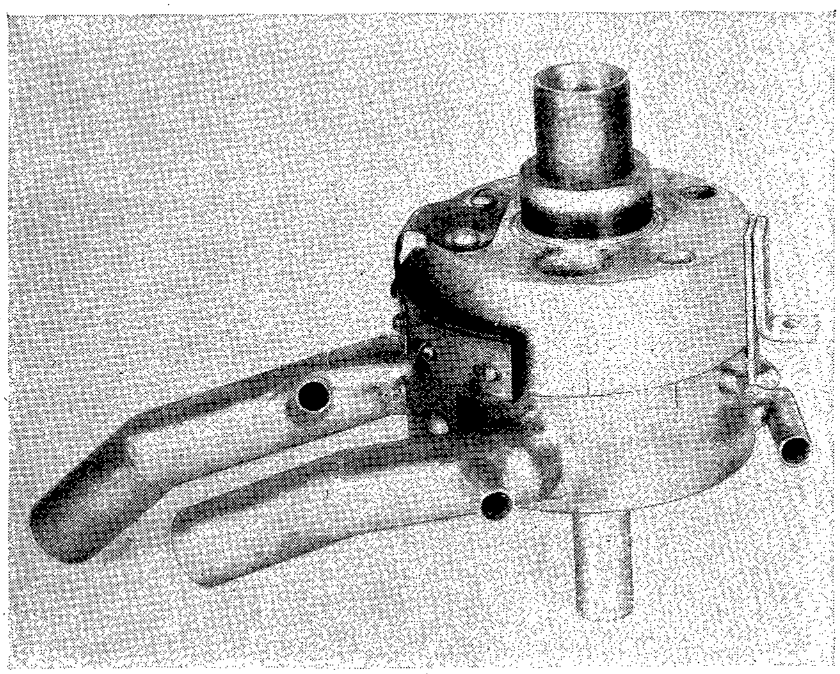


FIGURE 6.—Rudder valve.

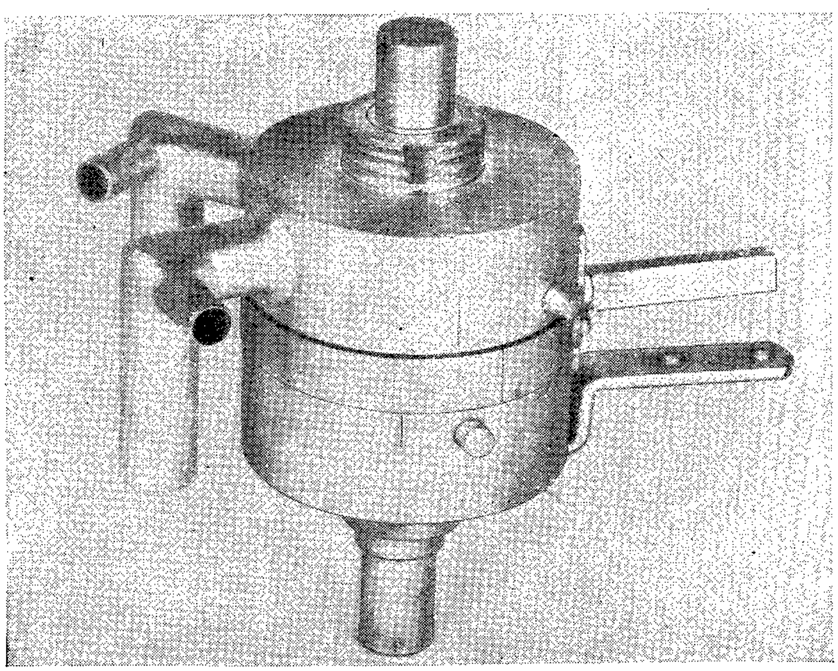


FIGURE 7.—Aileron valve.

(*b*) The aileron valve is located just behind the pilot's seat on the left-hand side, mounted in a horizontal position, and connected to and operated by the aileron control (wheel or stick). Movement of the trainer, caused by the aileron valve, is around the longitudinal axis and is called banking.

(*c*) The elevator valve is located under the pilot's seat on the left-hand side and to the rear, and is mounted in a vertical position. It is connected to and caused to operate by the elevator control or stick (fore and aft movement). Movement of the trainer caused by the elevator valve is about the horizontal or lateral axis and is called "pitching" or "climbing or diving".

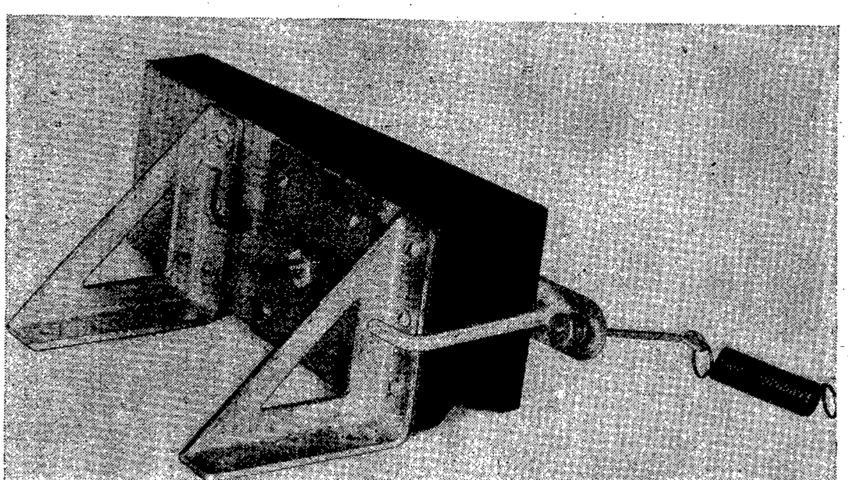


FIGURE 8.—Air speed and tachometer regulator bellows.

c. Regulating bellows (figs. 8 and 9).—(1) The three regulator bellows incorporated in the trainer are located as follows:

(*a*) *Air speed regulator bellows.*—Mounted on left bottom fuselage former in the rear of seat back.

(*b*) *Tachometer regulator bellows.*—Located slightly above and forward of the air speed regulator bellows.

(*c*) *Turn and bank indicator regulator bellows.*—Mounted on rear of altitude tank in the nose of fuselage.

(2) These bellows are constructed primarily of wood and rubberized fabric hinged by the fabric so as to permit expansion and contraction on one end only. Their purpose is, as the name implies, to regulate the flow of atmosphere, in the system of which they are a part, by means of a taper pin and seat located inside of the bellows.

d. Climb-dive valves (fig. 10).—The climb-dive valve assembly is located in the fuselage floor under the seat on the left side directly below the lateral axis. This assembly is composed of two needle valves mounted on a metal support and is controlled by means of

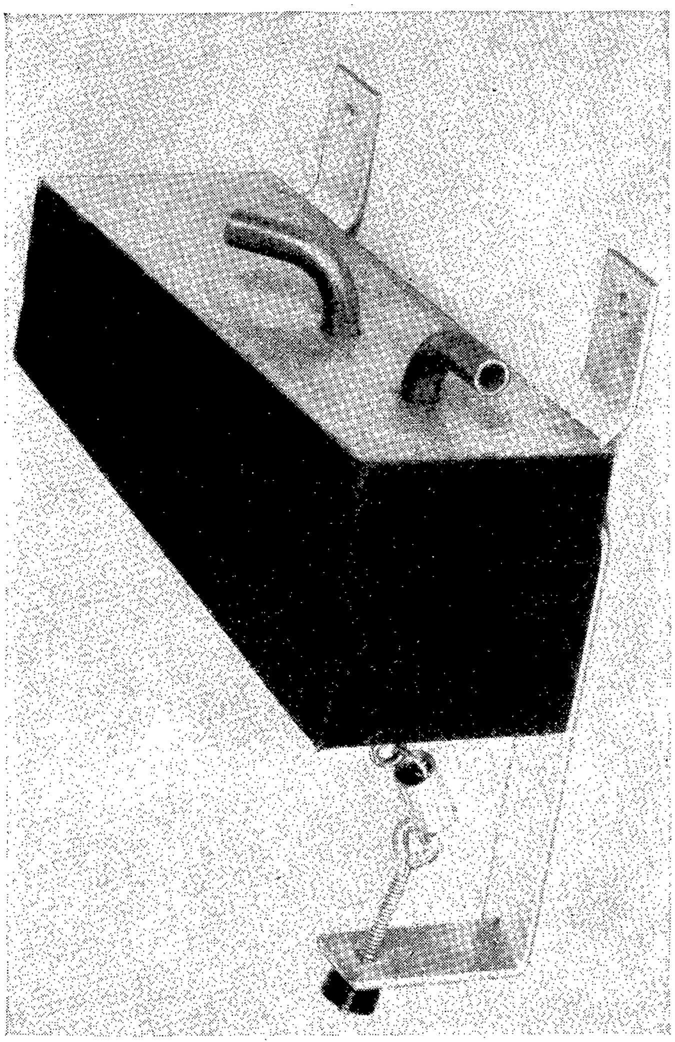


FIGURE 9.—Turn and bank indicator regulator bellows.

the trainer's differential linkage as a unit, controlling, in part, the flow of atmosphere in the trainer altitude system. The forward needle valve is the "dive" valve and the rear the "climb" valve. Located on the end of each needle valve body is a small valve known

as a "limit" valve that serves as an adjustment to limit the flow of atmosphere through the line in which it is located.

e. Tanks.—Located in the nose of the trainer, mounted on the nose panel, are the two vacuum tanks incorporated in C–2 and C–4 trainers; the altitude tank (fig. 11) and the air speed damping tank (fig. 12). C–3 and C–5 trainers differ from the above only in that—

(1) The larger of the two, the altitude tank, has a diameter of approximately 11 inches, and is constructed of aluminum, with a

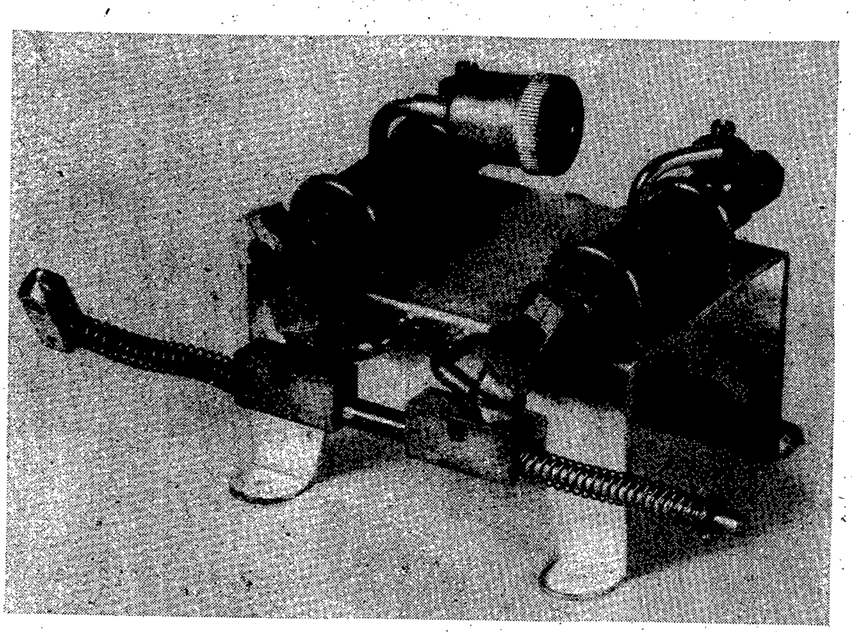


FIGURE 10.—Climb-dive valves.

plywood insert in one end to which the turn and bank indicator regulator bellows is mounted. By partially evacuating the atmosphere from this tank, a condition is caused to exist that parallels actual conditions encountered by an ascending airplane, that is, altitude is created and indicated by the instruments connected to this tank.

(2) The air speed damping tank is a small aluminum tank approximately 4 inches in diameter, mounted at the right side of the altitude tank on the nose panel of C–2 and C–4 trainers and in the top rear of the fuselage on later models, and serves, as its name implies, to smooth out the flow of atmosphere in the air speed line, of which it is a part. Located on the face of this tank is a small

bleed hole of .025 inch on C–2's and C–4's and .040 inch on C–3's and C–5's. The function of this bleed hole is to allow atmosphere to enter the air speed system, and also to further dampen the flow of atmosphere in that system.

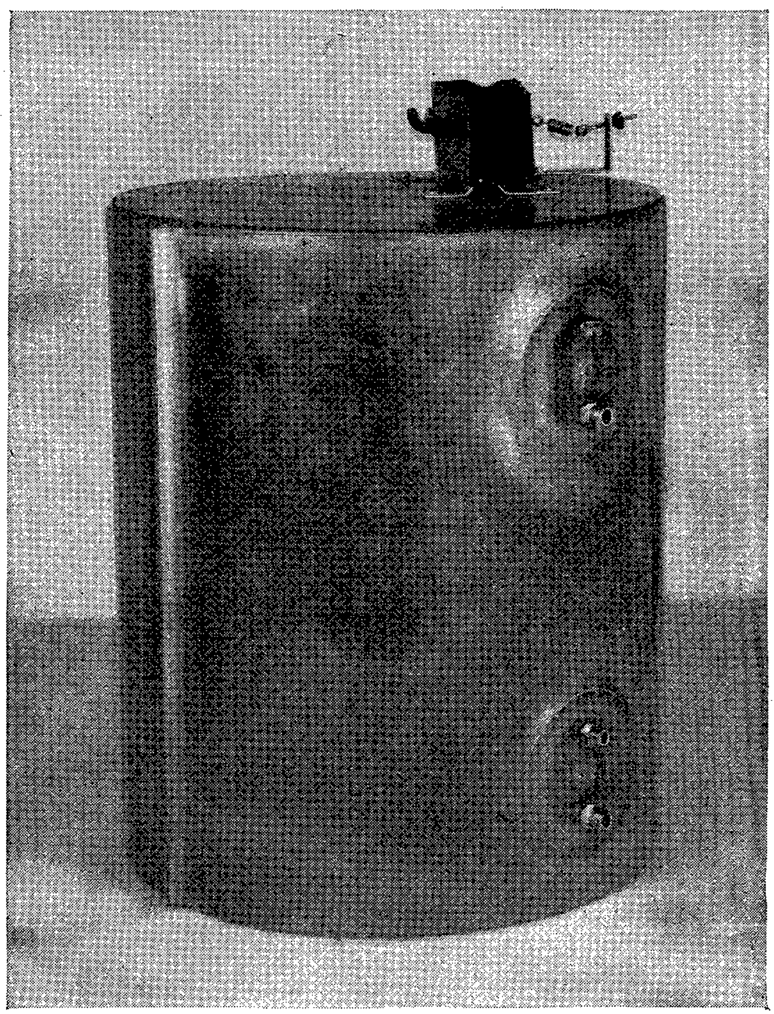


FIGURE 11.—Altitude tank.

(3) On C–2 trainers an additional tank, known as the air speed compensating tank, is found in the air speed system, located in the rear of the fuselage mounted on the back of the rear panel. This tank is of the same construction as the altitude and damping tanks, and serves the same purpose as the small damping tank. A bleed

hole of .025 inch is drilled in this tank, while the damping tank for a C-2 trainer has a bleed hole of .018 inch.

f. Stall valve assembly (fig. 13).—(1) When the speed of an airplane drops below a certain minimum, the airplane "stalls", and

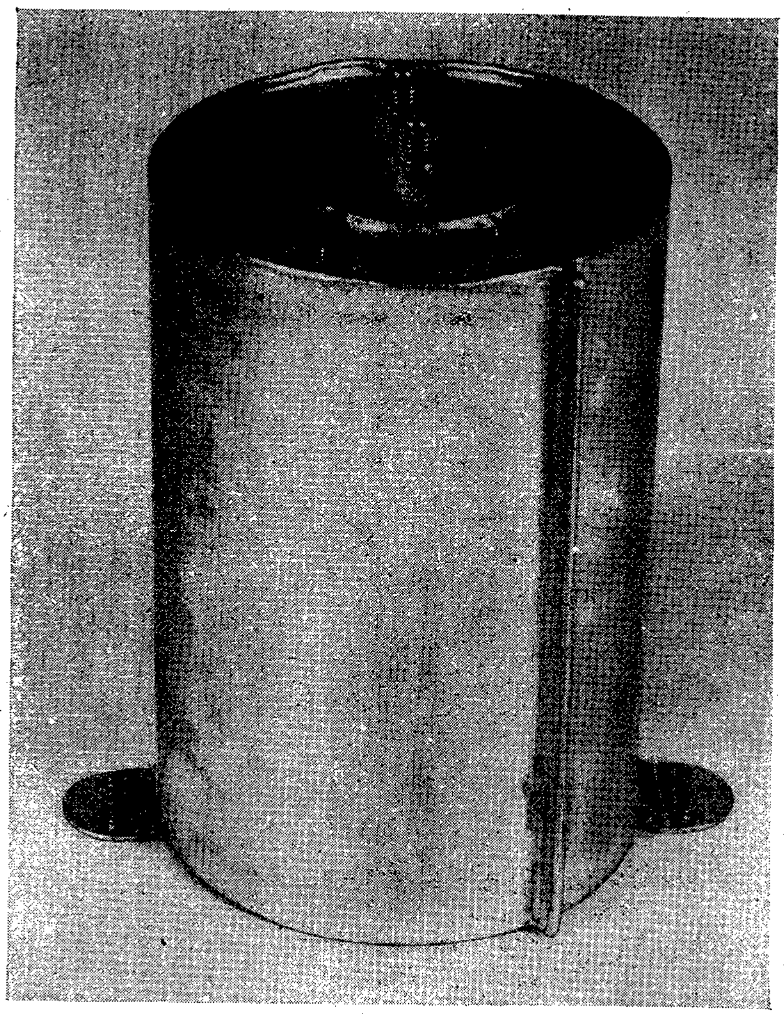


FIGURE 12.—Air speed damping tank.

sometimes starts to "spin". This characteristic is built into the trainer and is the function of the stall valve assembly.

(2) The stall valve assembly is located on the fuselage floor beneath the pilot's seat on the right-hand side, and to the rear. It consists of a brass valve body with a steel needle shaft to which is fastened an inverted pendulum which operates, under certain con-

ditions, between two stops. The pendulum is caused to operate by a link rod which is fastened to the stall valve bellows, it being mounted on an extension of the rear pendulum stop. The brass valve body is

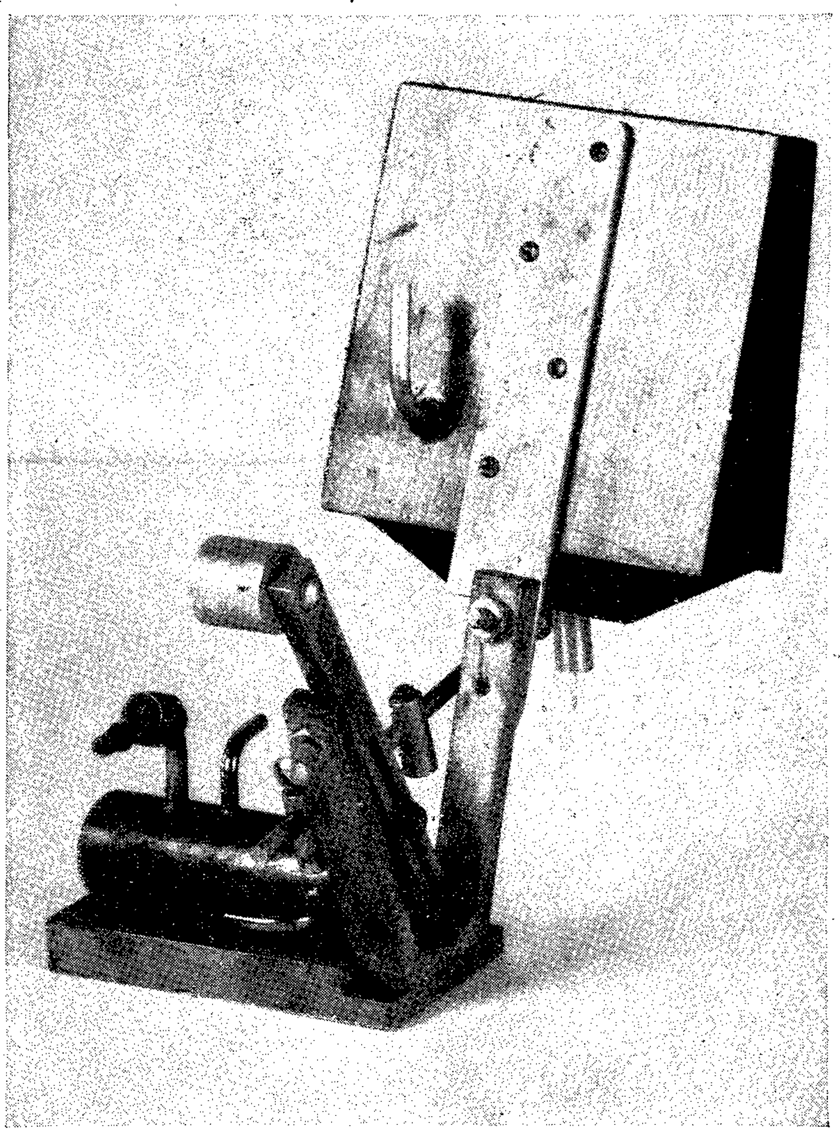


FIGURE 13.—Stall valve assembly.

two valves in one. One valve is the needle type valve and is called the "mush" valve. The other valve is the common gate type valve and is called the "spin-trip" valve.

g. Spin valve (fig. 14).—(1) The spin valve is a simple two-way valve with a brass valve body and steel core to which is attached an inverted pendulum, which operates between stops, and is caused to operate either by movement of the rudder bar or by banking action

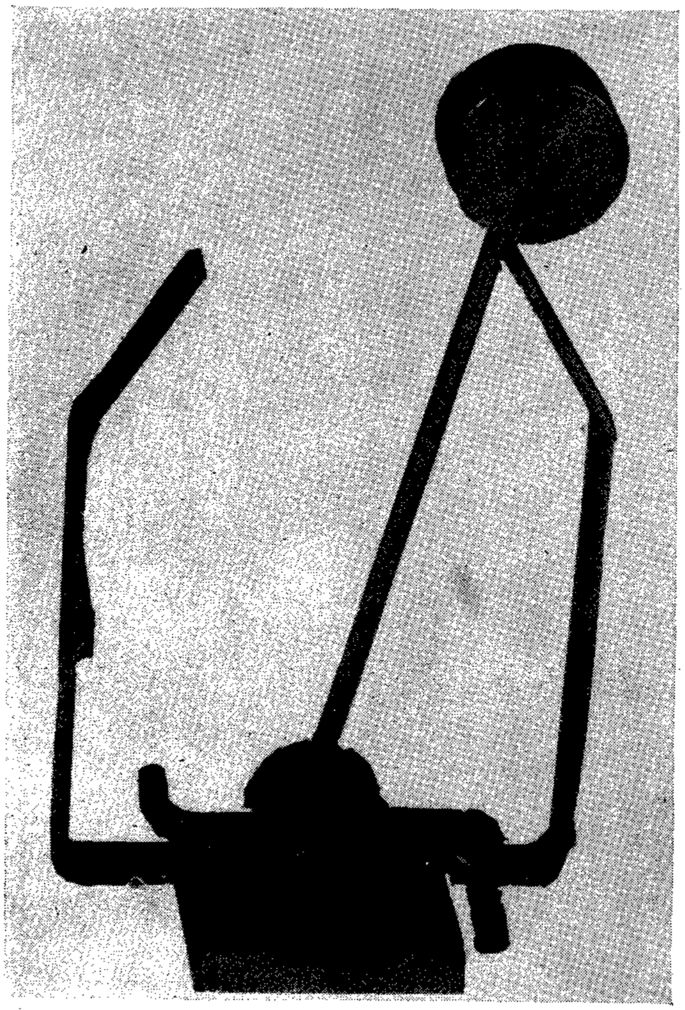


FIGURE 14.—Spin valve.

of the trainer. The valve is located beneath the pilot's seat on the longitudinal axis, and to the rear.

(2) The function of the spin valve is to determine in which direction the trainer will rotate in a spin.

h. Bank-turner, spin-trip assembly.—The bank-turner, spin-trip assembly is two assemblies built into one, and serves to provide two automatic features: automatic turn and automatic spin (see fig. 15).

(1) Automatic turn is accomplished through the bank-turner portion of the bank-turner, spin-trip assembly.

The bank-turner portion consists of a solid shaft mounted and free to turn in two brackets. On the right-hand end of the shaft is a bell crank to which is connected a walking beam. On the left-hand end is a horizontal arm to which is connected a link rod, which in turn is fastened to the revolving-octagon iron cross on the lateral

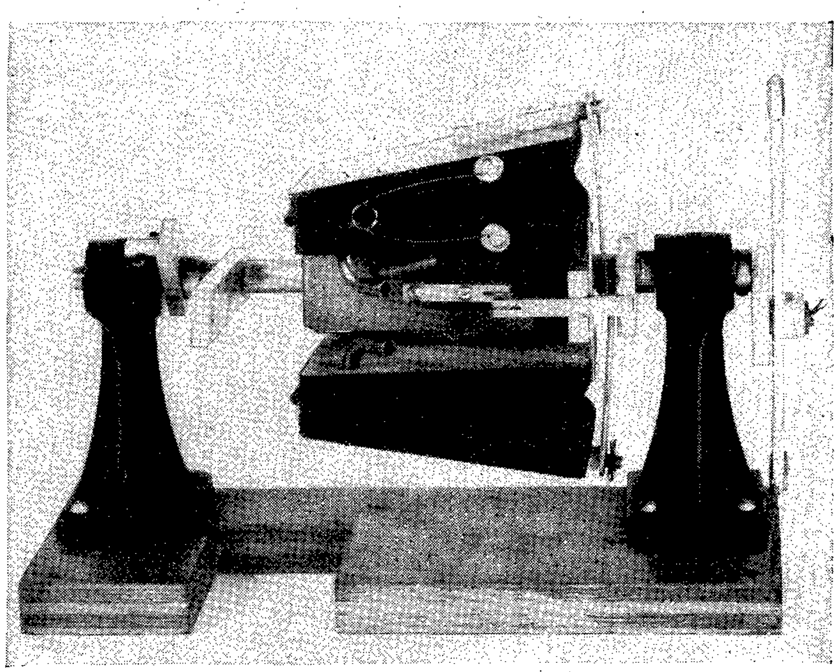


FIGURE 15.—Bank-turner, spin-trip assembly.

axis by a universal stud bolt. The whole assembly is mounted on the fuselage floor, beneath the pilot's seat, to the right of the longitudinal axis and parallel to the lateral axis.

(2) Automatic spin is accomplished through the spin-trip portion of the bank-turner, spin-trip assembly. The spin-trip assembly consists of a bellows and latch assembly using three bellows, one to operate the latch, and two to provide energy for actuating the rudder valve when spinning, mounted on a hollow shaft, which in turn is mounted on the solid shaft of the bank-turner portion.

(*i*) *Instrument panel.*—(1) The instrument panel (fig. 16) is essentially the same for all trainers. All instruments included on C–2 panels are the same in later models except for slight changes in location. All trainers include the following listed instruments:

(*a*) Magnetic compass.
(*b*) Directional gyro (turn indicator).
(*c*) Artificial horizon (flight indicator).
(*d*) Altimeter.
(*e*) Air speed indicator.
(*f*) Turn and bank indicator.
(*g*) Vertical speed indicator.
(*h*) Tachometer.
(*i*) Radio compass indicator.
(*j*) Visual marker beacon lamp.
(*k*) Clock.

(2) On late trainers, the C–5 and C–3, a gas gage is included on the panel which is nothing more than a clock works operated electrical relay, which interrupts the main electrical circuit of the trainer when the "gas supply" is exhausted.

(3) The C–5 trainer also includes a small radio receiver mounted on the right-hand lower side of the panel. The "line switch" common to C–2 and C–4 trainers has been changed from the lower left-hand side of the panel to the middle right side and renamed "ignition switch." The purpose of this switch is to make and break the main electrical circuit supply of the trainer.

(4) The C–2 model has, located on the right side, a small "radio control" panel including jacks for the microphone and headset, a radio volume control, and a call signal switch. C–2 and C–4 models include on the instrument panel a rheostat, marked "Volume," that serves as the volume control for the radio compass indicator. The radio control panel and the volume control for the radio compass indicator have been removed from the panel of the C–5 and C–3 trainers and incorporated in a control box mounted on the right side of the fuselage. The C–4 model also incorporates the radio control panel on a separate control box.

(5) Located in the left-hand lower corner of early C–2 models, is the throttle assembly consisting of a simple push-pull, plunger type throttle; on the later models this has been replaced by the conventional throttle assembly located on the left side of the fuselage.

j. Throttle assembly.—(1) The throttle assembly (fig. 17) is located on the left side of the cockpit just forward of the door on late C–2 trainers and all subsequent models.

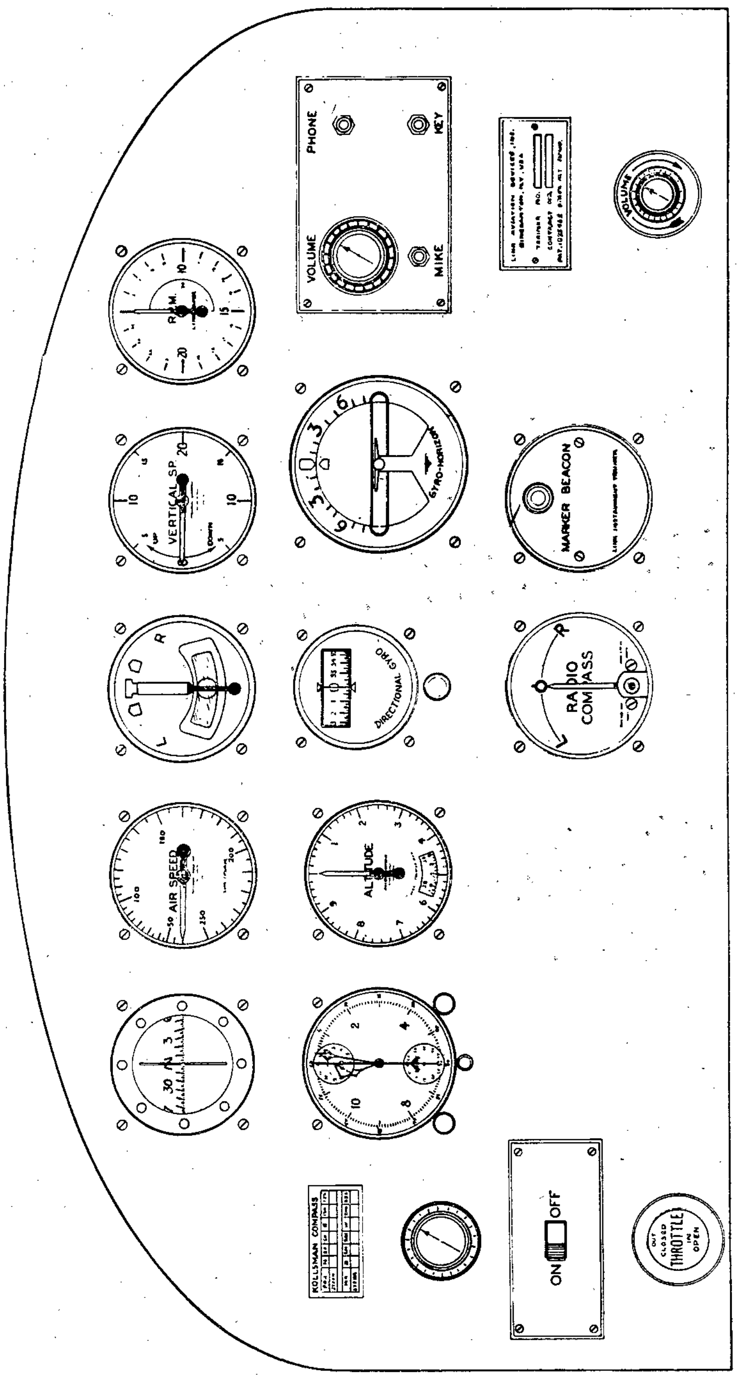


FIGURE 16.—Instrument panel, C-2.

(2) This assembly is of the conventionel quadrant type and serves, through its direct linkage to the differential linkage, to duplicate the functions of an airplane throttle. The throttle is opened when pushed forward and closed by retarding.

(3) Early model C-2 trainers incorporate the push-pull plunger type throttle on the instrument panel connected into the differential linkage by a cable arrangement which in most cases has proved unsatisfactory.

k. Pitch action assembly.—(1) The purpose of this assembly (fig. 18) is to provide the necessary changes to the various valves and regulator bellows so that proper instrument indications will be received when pitching action of the trainer takes place.

(2) This assembly is located under the seat with its length parallel and to the rear of the lateral axis of the trainer, and consists of a solid steel torque rod 11¾ inches long, on the right end of which is attached a lever arm, known as the "horizontal lever arm." From the rear end of this lever arm a subassembly called the "main spring compensator" extends down and is attached to the iron cross of the revolving octagon on the longitudinal axis by means of a small universal stud bolt. Approximately midway of this torque rod is a second arm called the "vertical arm." To this arm is attached the linkage and levers of the stall valve assembly. The torque rod is supported by an angle bracket on one end and a pedestal bracket on the other. On the left end of the torque rod is attached the bell crank and to it the walking beam, to which are attached the various differential linkages.

l. Reversing arms.—(1) A reversing arm is a mechanical means of reversing the direction of motion of a force applied to the linkage system of which it is a part.

(2) There are three reversing arms used in all trainers: one in the air speed linkage, one in the tachometer linkage, and one in the stall valve linkage. Some C-2 type trainers, due to the construction of the throttle, use a reversing arm in the throttle linkage.

m. Link rods.—(1) There are two types of link rods used in the trainer, plain link rods and compensator link rods.

(2) Any link rod is a mechanical means of transfering energy or motion from one point to another. A plain link rod is a piece of metal rod or any suitable substance that is used to transfer all of the motion or energy from one point to another. A compensator link rod is two pieces of metal rod or any suitable substance fitted together in a sleeve, with springs of the compression type fitted onto the two rods and the sleeve in such a manner that for all purposes the combined rods serve the same purpose as a plain link rod, until the

point to which the energy or motion is being transferred reaches a stop, then any further movement of the point from which the energy is being transferred will be expended in or compensated for by the compressing of the springs. Any sudden or violent motions on the

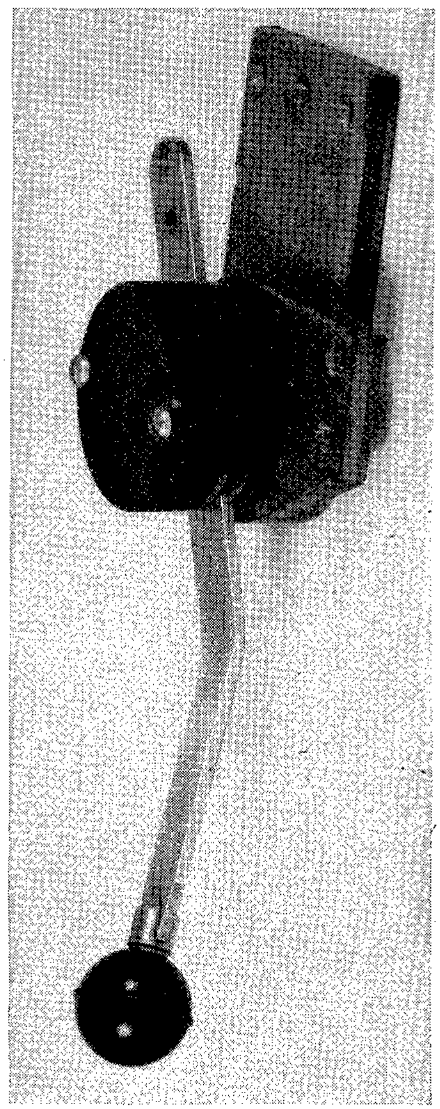


FIGURE 17.—Throttle assembly.

part of the point from which the motion is being transferred is compensated for or the action smoothed out by the compensator link rod springs.

n. Hook-up sockets.—The four bellows hook-up sockets are located in the fuselage floor directly above the four main bellows which they serve; two on a line with the longitudinal axis serving the fore and aft pitching bellows, and two on a line parallel to the lateral axis serving the banking bellows. These sockets are merely formed metal inserts screwed to the fuselage floor over a hole through which the bellows stud bolt extends. The concave portion of these sockets serve as a receptacle for the half round bellows ball nut that secures the bellows stud bolt in place and so forms a universal hook-up for the bellows to fuselage arrangement. The front socket is located just in

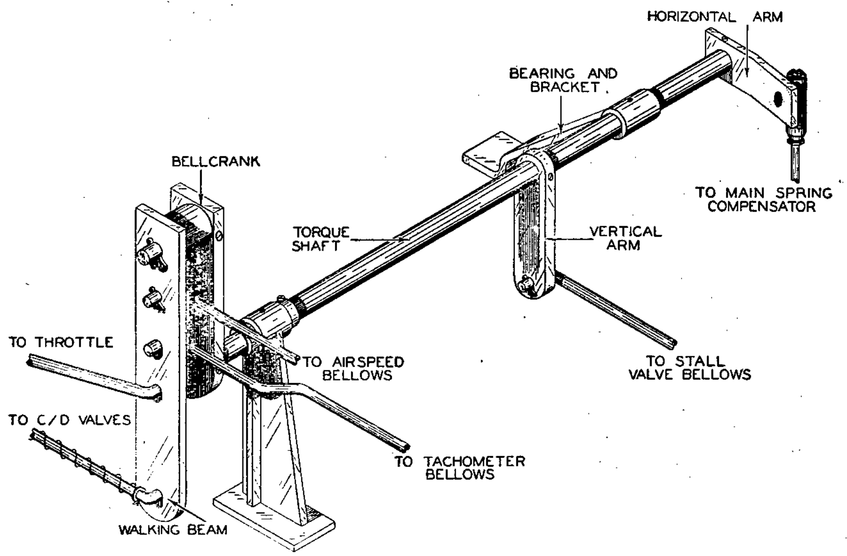


FIGURE 18.—Pitch action assembly.

front of the control column; the rear, approximately 5 inches in front of the rear hook-up bar. The left socket is beneath the climb-dive valve assembly and the right socket just off the right end of the bank turner spin-trip assembly.

o. Rough air mechanism.—(1) This mechanism (fig. 19) is a system for causing bumps or simulating rough air conditions encountered in actual flight.

(2) It is made up of a system of cam-operated flap valves actuated by the rear fan motor, or a special electric motor and gear train in very late C-3 models, which upset the balance of air in the various control bellows. This assembly is located under the seat at the extreme right-hand rear corner with the crank for controlling its operation accessible from underneath the right-hand side of the tail of the fuselage.

p. Slip stream simulators.—(1) Slip stream simulators are used on the instrument flying trainer to simulate the resistance offered control movement of an airplane by the flow of atmosphere over the control surface.

(2) All trainers use some form of hydraulic slip stream simulator on both the elevator control and the rudder control.

(*a*) The elevator simulator is mounted forward of the control column or stick on the fuselage floor or on a bracket fastened to the

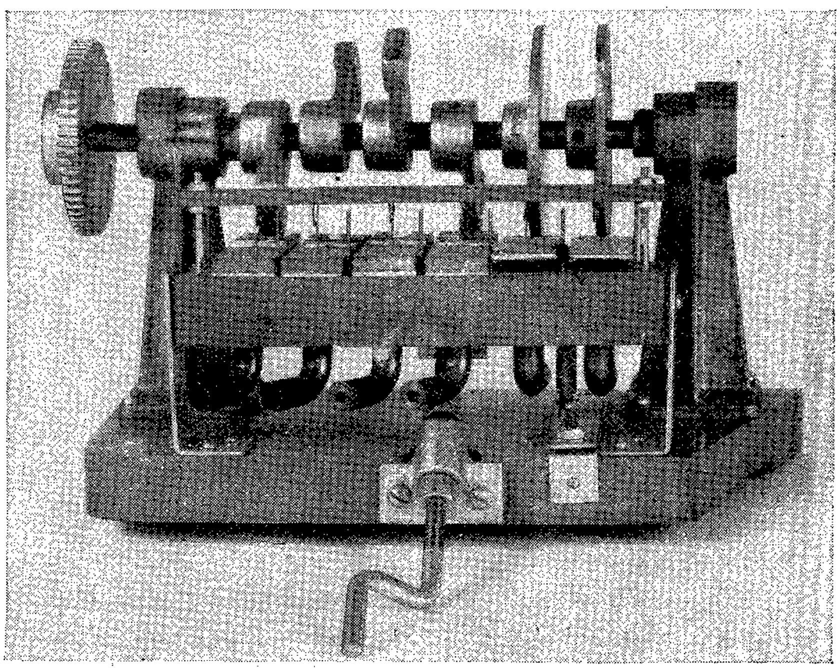


FIGURE 19.—Rough air mechanism.

floor and is connected to the control column or stick by means of a link rod.

(*b*) The rudder simulator is mounted on the fuselage floor in line with the control column or stick and is connected to the rudder bar by means of a link rod.

(3) Wheel control trainers of the C–4 and C–5 types have the elastic or shock cord type simulator which is a piece of $\frac{3}{16}$-inch shock cord fastened to the lower center point of the control wheel at one end and fastened to the control column at a point 8 inches below the rim of the control wheel. This shock cord, housed in a metal telescopic housing, can be lengthened or shortened to any desired

length to change the amount of resistance offered to control movement.

(4) C-3 model trainers incorporate a different type control column, covered in detail in section IV, that mounts a hydraulic slip stream simulator, of the same type as the rudder and elevator units, on the torque rod of the aileron control.

q. Icing valve.—The icing valve is located in the air speed line running along the bottom right fuselage former, slightly to the rear of the back panel. This valve is an ordinary screw type shut-off valve operated by a thumbscrew. When this valve is closed (screwed in) it blocks the air speed line and thereby simulates the icing of the pitot tube of an airplane.

r. Compass deflector.—The compass deflector is an assembly located directly underneath the magnetic compass on the rear of the instrument panel with the switch governing its operation attached as a part of the rudder valve. (See fig. 6.) This assembly is included as a part of the trainer to simulate northerly turning error in the magnetic compass and is composed of a small electromagnet mounted directly under the compass.

s. Control box.—(1) Trainers of the C-4 type and all subsequent models have located on the right-hand side of the cockpit wall a control box which serves as a mounting for the various electrical controls pertinent to that model and also as a junction box for various electrical circuits incorporated in the trainer fuselage.

(2) The control box common to C-4 trainers is an oblong metal box having mounted on the face the following controls: The call switch and the radio volume rheostat. In addition to the foregoing the C-4 Special E trainers have the landing path indicator volume control and the flight path indicator on-off switch. On the rear side of this box are the microphone and phone jacks.

(3) The C-5 and C-3 trainers have a considerably larger control box serving the same purpose but housing more electrical circuits and supporting more and different controls. The controls mounted on the top surface of the C-5 control box are as follows from front to rear: Cockpit light dimmer, rim light dimmer (instruments), radio compass sensitivity rheostat, simultaneous voice-range switch and the radio off-on switch. Two phone (headset) jacks and one microphone jack are located on the rear side of this box. This box also contains, in addition to several electrical circuits, an interphone amplifier unit.

(4) The following controls are provided on the control box of the C-3 model: radio volume, for controlling the radio signal level in the earphones; station selector, for selecting either range, inner or

outer marker stations; radio compass sensitivity; call switch and cockpit light dimmer.

t. Radio loop antenna.—The radio loop antenna, used in conjunction with the radio compass, is a large metal-covered loop mounted on top of and in the center of the hood with the base of the loop extending down into the inside of the hood to a control with which to rotate the loop, and a small azimuth scale by which to determine the number of degrees the loop has been rotated. This assembly is common only to the C-5 model.

u. Lights.—(1) All trainers incorporate two adjustable 12-volt lights, one mounted on the cockpit door and the other mounted on the top longeron on the right-hand side serving as direct lighting for the instrument panel, maps, charts, etc., carried by the pilot.

(2) In addition to the small adjustable "spots" the C-5 trainers incorporate instrument rim lights on all instruments. The C-5 trainer has also a small light furnishing direct lighting of the azimuth scale of the radio loop antenna located in the hood.

(3) Two fluorescent lamps are provided on C-3 models replacing the rim lights common to C-5 models.

v. Trainer locking (leveling) devices.—Two separate devices are provided with which to lock the trainer in a level position when it is not in use or when adjustments are being made.

(1) One system consists of two simple straps as illustrated in figure 21. The other system consists of a hydraulic jack operating a lever arm which in turn pulls four cables attached to four points on the octagon to pull the fuselage to a level position and hold it there (see fig. 22). The first system (lock straps) is used primarily for making adjustments within the trainer fuselage where the "locked level" position is used as described in section IV. When the lock straps are thus being used, the other system must be released.

(2) The second system (hydraulic) is used primarily for locking the trainer in a nearly level position when students are mounting or dismounting the trainer. When the hydraulic system is being used, the side and rear straps should be "off" and resting in their keepers.

w. Remote instrument transmitter panel.—(1) The remote instrument transmitters are mounted on a panel in the rear part of the fuselage directly behind the rear seat. This panel is common to all C-4, C-5, and C-3 trainers and is composed of the master instruments and the electrical Telegon transmitters for the remote altimeter, vertical speed, and air speed indicators located on the instrument panel and the desk instrument panel.

(2) Mounted on the lower left side of the panel is the relatively small assembly of the air speed transmitter; mounted in the center of the panel is the large assembly of the vertical speed indicator with the sensitive altimeter transmitter mounted on the lower right corner.

(3) C-2 models do not incorporate the Telegon system of remote indicating instruments.

x. Power supply.—(1) Mounted directly below the remote instrument transmitters on the C-5 trainers behind the pilot's seat is the fuselage power supply. Its function is to supply all operating voltage for radio, interphone, relay, microphone, and lighting within the trainer fuselage, and consists of one lighting transformer, one power transformer, two filter chokes, one filter capacitor, and cable leading to the fuselage control box.

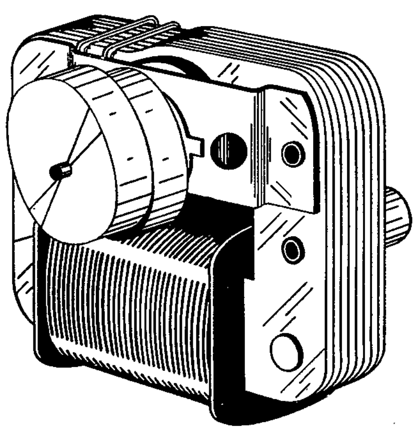


FIGURE 20.—Vibrator motor.

(2) All trainers previous to this model mount a single transformer on the rear side of the instrument panel that furnishes the proper power supply to the cockpit lights and the compass deflector.

y. Vibrator motors (fig. 20).—(1) Vibrators are used in the instrument flying trainer to set up a vibration in the instruments causing them to operate smoothly. With lack of vibration the instruments will be sluggish and incorrect. These vibrators consist of a small, electric motor with two adjustable eccentric flywheels mounted on the armature shaft.

(2) On all C-2 type trainers there is only one vibrator motor used. It is mounted on the back of the instrument panel in the vicinity of the lower right-hand corner. On trainers later than the C-2 there are three vibrator motors used: one on the cockpit instrument panel, one on the desk instrument panel, and one on the transmitter panel. The

one on the desk instrument panel is mounted on the back side of the panel within the instrument case above and between the altimeter and the air speed indicator. The one on the transmitter panel is mounted on the face of the panel, below the vertical speed transmitter and between the air speed and altimeter transmitters.

z. Controls.—(1) Trainers are delivered with either stick or wheel and column controls serving the elevators and ailerons. The wheel and column controls are mounted by a bracket arrangement to the floor of the fuselage just forward and on the line parallel to the longitudinal axis of the trainer. The wheel controls the motion of the trainer about the longitudinal axis by movement of the aileron valve and gives banking or rolling motion to the trainer. Movement of the control column either forward or to the rear moves, through linkage, the elevator valve and so controls movement of the trainer about the lateral axis causing pitching action. The stick control performs the same functions as the wheel and column control by movement of the stick fore or aft for pitching movement and to right or left for banking movement of the trainer.

(2) The C-3 trainer is equipped with a mechanism whereby the controls may be changed from wheel to stick control in a very short time.

(3) The rudder pedals are mounted on the fuselage floor in the nose of the trainer and are used to control the movement of the trainer about its vertical axis causing turn or yaw to take place.

(4) The movement of these controls not only causes movement of the trainer about its axes but also move the rudder, elevator, and aileron control surfaces of the empennage and wings.

aa. Empennage and wings.—The empennage and wings are included in the make-up of the trainer primarily to aid the instructor in determining the attitude of the trainer and to make it possible for the instructor, by watching the control surface, to determine just how smoothly and accurately the student handles the controls.

(1) The wings are constructed and covered much in the same manner as airplane wings of the fabric covered type but are mounted merely by screws and brace rods.

(2) The empennage is a lightly constructed, fabric covered, metal framework. The stabilizers are mounted on the tail of the fuselage with screws and braces. The rudder and elevator are mounted on their respective stabilizers with hinges. The rudder and elevator are connected to their respective controls by means of linkage and any control movement affects the control surfaces.

ab. Fans.—All C-2, C-4, and C-5 trainers are equipped with two ventilating fans. One in the nose is mounted on the bottom of the

panel, which is an intake fan, that is, it draws fresh atmosphere from the outside of the trainer and blows it toward the pilot. The other is mounted on the fuselage floor under the pilot's seat. It draws the stale air out of the cockpit and expels it through the rear of the trainer. The rear ventilating fan also drives the rough air mechanism on the C–2, C–4, and C–5 trainers. On C–3 type trainers, the rear ventilating fan is omitted and a small 110-volt motor is in its place to drive the rough air mechanism.

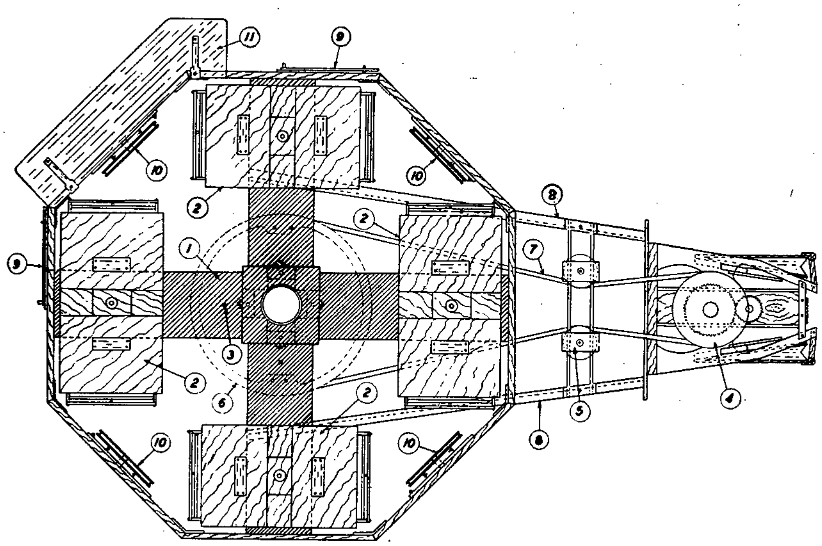


FIGURE 21.—Octagon—top view.

5. Octagon.—The following units and subassemblies are part of the trainer revolving octagon (figs. 21 and 22):

a. Octagon former.—The wooden sides of the octagon (fig. 23) are 7 inches high and approximately ¾ inch thick and serve to form the octagon and to mount the step and the heading reference markers. The left and rear hook-up straps are also mounted to these formers.

b. Octagon iron cross.—The revolving octagon iron cross is the large iron cross used as a platform to support all other members of the revolving octagon. Attached to the iron cross is the wooden frame which forms the octagon. The iron cross sets over and is keyed to the spindle by two large setscrews.

c. Main (banking and pitching) bellows.—(1) The banking and pitching bellows (fig. 24) are made of four pieces of wood (top, two middle sections, and bottom) and are covered with rubberized fabric. Four of these bellows are used with the bottoms fastened to the iron

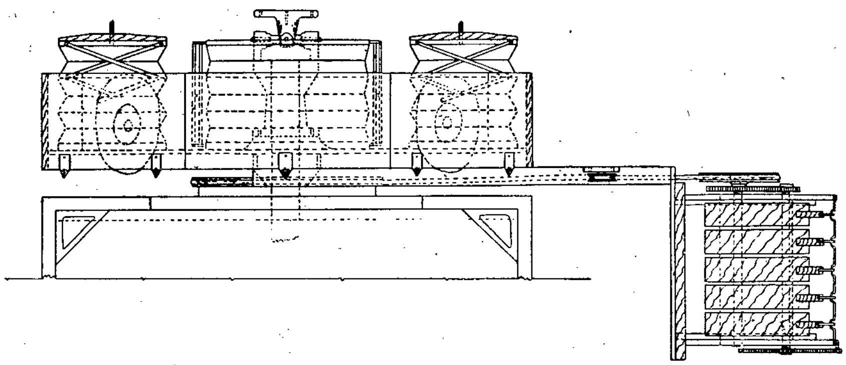


FIGURE 22.—Octagon—side view.

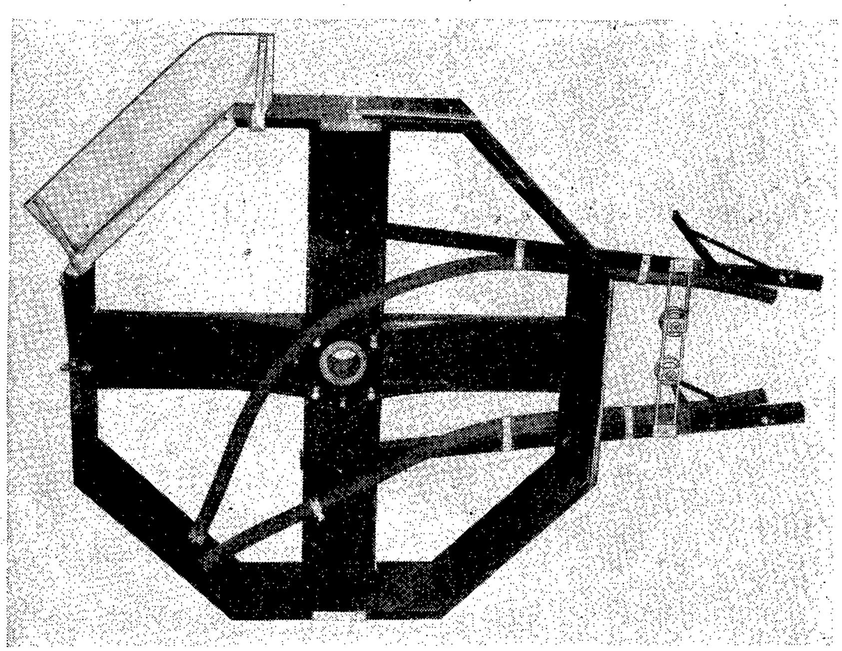


FIGURE 23.—Octagon.

cross and the tops fastened, through a linkage, to the bottom of the trainer fuselage into the bellows hook-up sockets. Two of the bellows are for banking and two for pitching, the latter being of slightly larger construction. Several holes are in the top of each bellows

covered by a flap so that if a bellows is pushed together when no vacuum is being applied, the air can escape and damage is prevented. These flaps are stretched tightly over the holes forming an airtight escape valve.

(2) On the ends of each bellows is a metal "scissors" arrangement to force the bellows to expand and contract squarely without any tendency to run over or collapse unevenly.

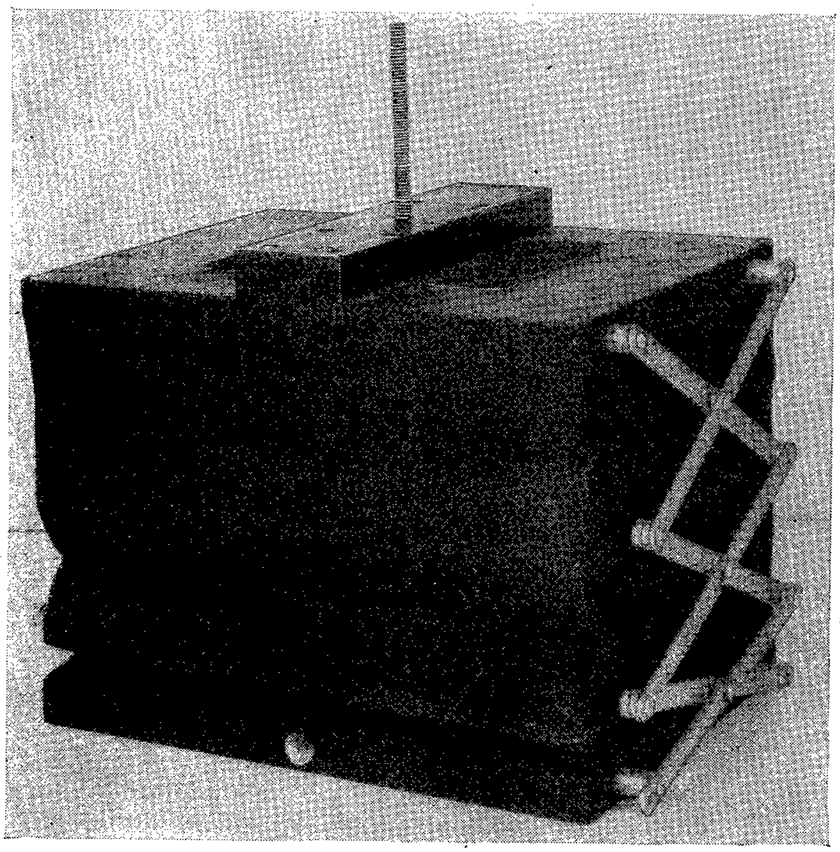


FIGURE 24.—Pitching and banking bellows.

d. Universal joint.—The main universal joint (fig. 25) is secured to the revolving octagon directly over its center by four stud bolts and serves to support the fuselage and at the same time permit bank and pitch of the fuselage of approximately 30°. It consists of a pedestal support with two bearing arms and a top mounting plate, for the fuselage, connected to the pedestal by means of a gimbal ring and bearings.

e. Universal studs.—(1) Mounted in the right and rear arms of the iron cross are the two universal stud bolts (fig. 26). The one on the right is the bank turner link rod universal stud, and the one on the rear arm is the pitch action spring compensator universal stud.

(2) These studs are mounted, the right on the lateral axis and the rear on the longitudinal axis, and are, as their name implies, small

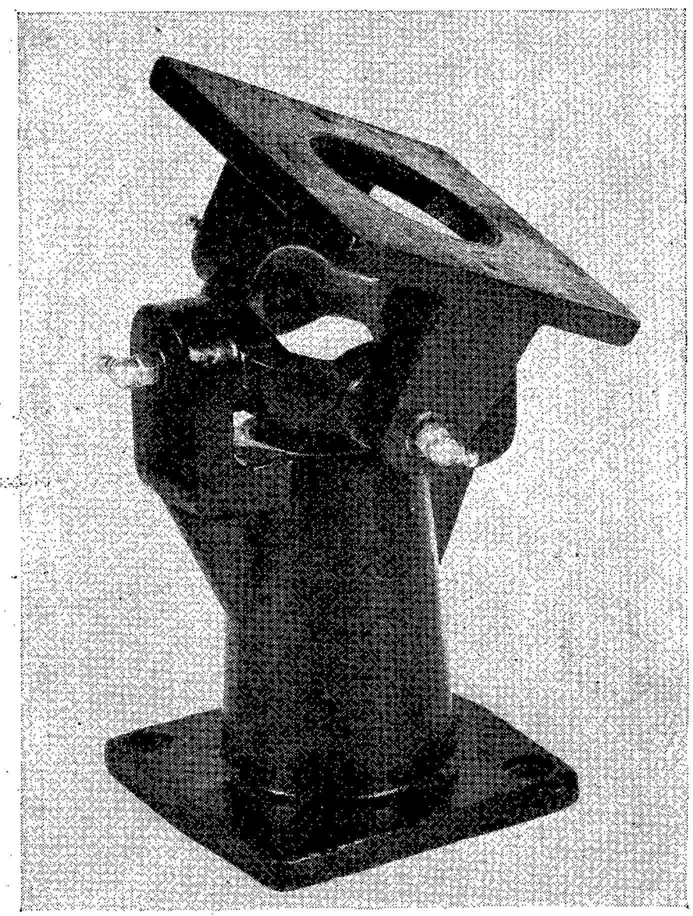


FIGURE 25.—Universal joint.

stud bolts that are screwed in or out for adjustment of the iron cross arm. The top of the stud is, in effect, a small universal joint and serves as such for the two linkages that must be attached to the iron cross.

(3) Later model trainers include the stud bolts but they are of slightly different construction, being a straight stud bolt with provisions for attaching the link rod but not having universal action.

f. Turning motor.—(1) The turning motor (fig. 27) is mounted to the front of the revolving octagon by means of angle iron brackets that are in turn secured to the iron cross.

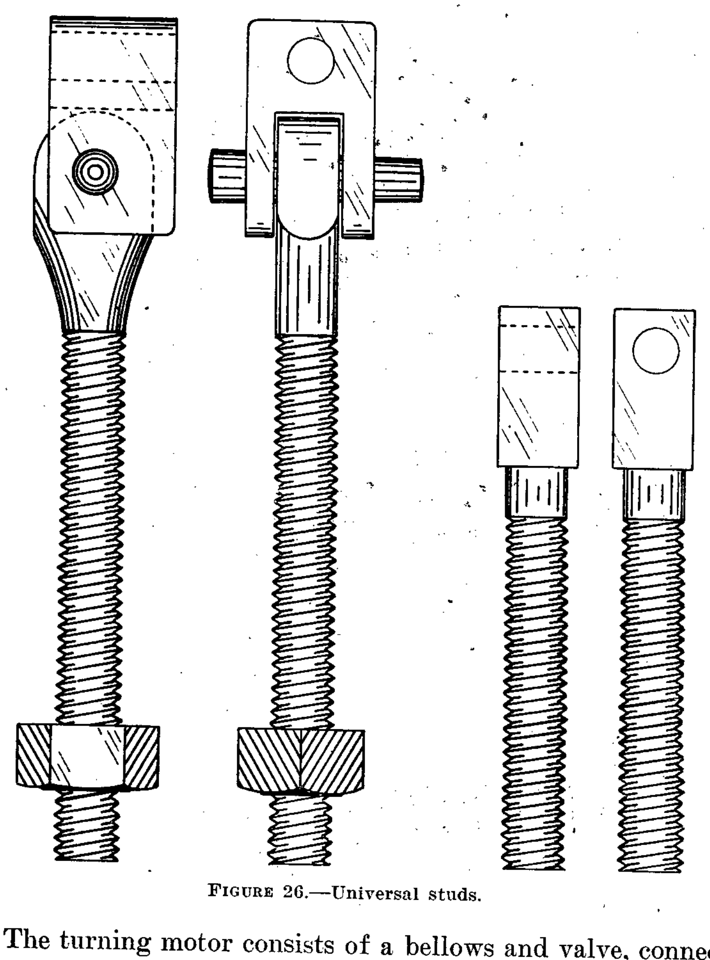


FIGURE 26.—Universal studs.

(2) The turning motor consists of a bellows and valve, connecting rod, crankshaft, and gear arrangement that is provided with a source of vacuum through hose connections to the rudder valve and provides a means of turning the trainer about its vertical axis, in a steady, smooth manner, by means of a laminated, round leather belt connecting the main turning motor pulley to the fixed pulley mounted on the iron cross of the base. This motor is provided with a metal hood that

is normally mounted over the turning motor for protection from dust, dirt, and other damage.

g. Belt tightener assembly.—The belt tightener assembly consists of two idler pulleys mounted on slide rods (fig. 21), which are in turn mounted to the angle iron supports of the turning motor, and are adjustable so that correct tension may be maintained on the turning motor belt.

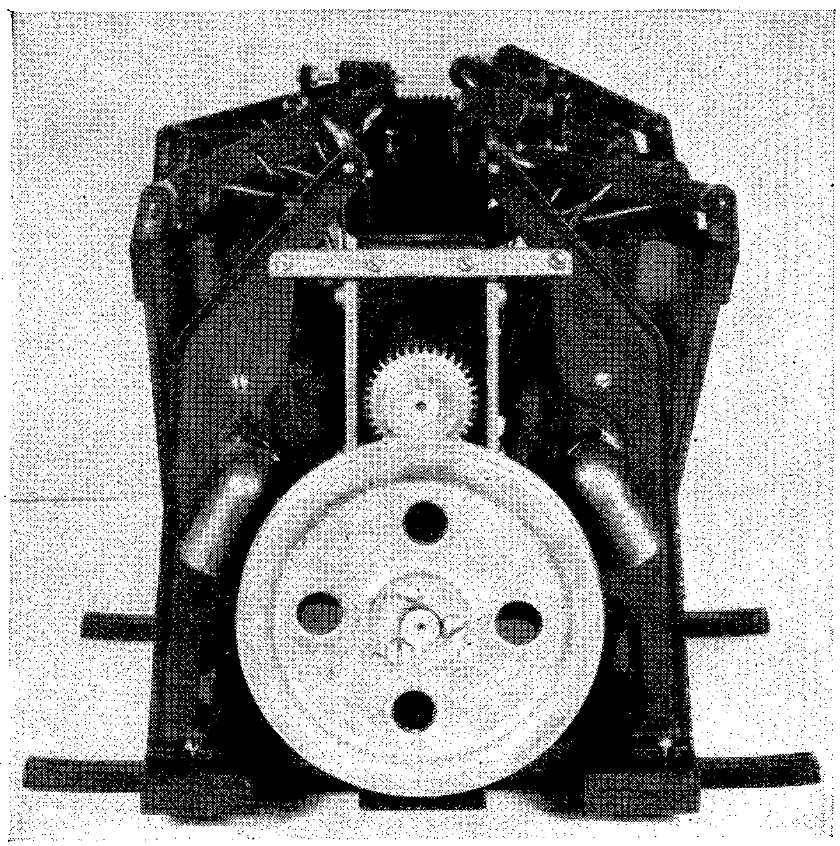


FIGURE 27.—Turning motor—top view.

h. Base belt pulley.—Mounted to the top side of the iron cross of the base is the base belt pulley (fig. 22). A cast iron pulley with ¾-inch groove approximately 15 inches in diameter, supported a distance of 3½ inches above the cross level by the two pedestals, which places it on the same level as the main turning motor pulley and the belt idlers.

6. Base.—Following are units and subassemblies of the trainer base (figs. 28 and 29):

a. Vacuum turbine.—(1) The turbo compressor or vacuum turbine (fig. 30) is used as a source of supply of vacuum for the entire trainer, and is driven by an electric motor which is mounted as a part of the complete unit.

(2) The turbo compressor is generally referred to as "the turbine." It is mounted in the base of the trainer, diagonally across one of the corners and facing toward the center of the base.

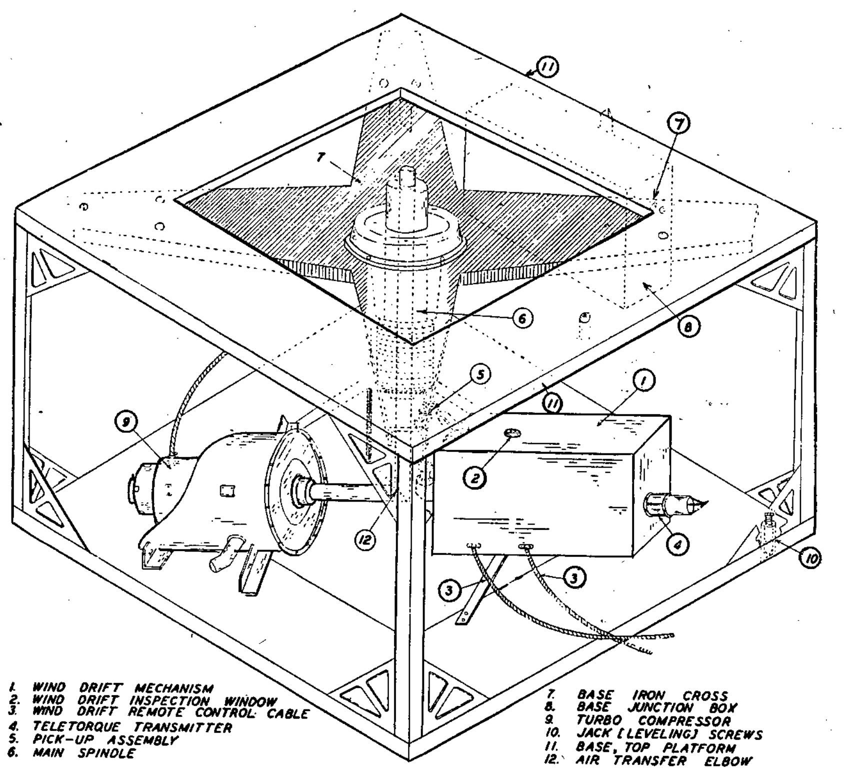


FIGURE 28.—Trainer base, C–5.

b. Junction box.—(1) Mounted in the trainer base, suspended from the bottom side of the top platform on the side normally facing the trainer desk, is the base terminal box (fig. 29). This box serves as the junction box for all electrical circuits from desk to trainer and base to fuselage. The 110V supply enters this box and is distributed through the junction wiring panel. Included inside the box is the magnetic starting relay common to all late C–2, C–4, C–5 and C–3 models. The

late C-2 models not having the main base terminal box, included this unit as a separate assembly.

(2) Mounted on the face of the box and extending through an opening provided in the base panel are the two switches and "tell-tale" neon lights for the main switch and oscillator unit. On the left side when facing this unit are the two 3-ampere fuses provided in the electrical system, and on the right side is the turbine switch which pro-

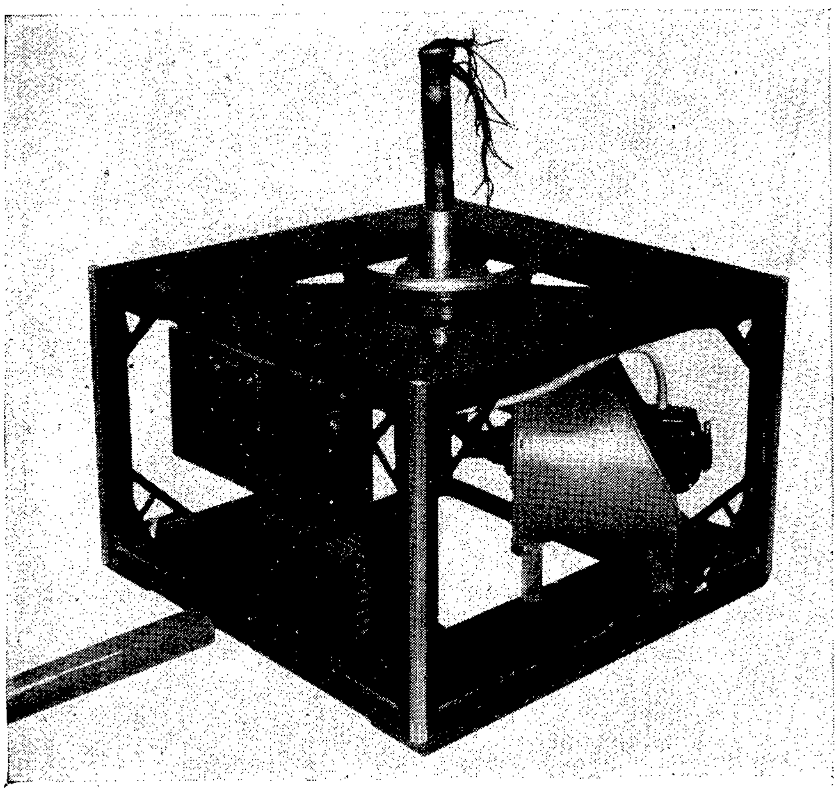


FIGURE 29.—Trainer base, C-4.

vides a means of shutting off the turbine and leaving the rest of the electrical system operative.

c. Telegon oscillator.—The Telegon oscillator (fig. 31) is contained in the metal box 8¼ by 7¼ by 10 inches and consists of a rectifier circuit and oscillator circuit that provides the proper voltage and frequency for operation of the Telegon remote instrument system. This complete unit is mounted on the base bottom platform slightly to the right and below the base junction box.

d. Leveling screws.—(1) There are four leveling screws provided in the base of the trainer, one in each corner of the bottom platform. (See fig. 28.) These leveling screws are provided for leveling the base with the floor, and are commonly referred to as "jack screws."

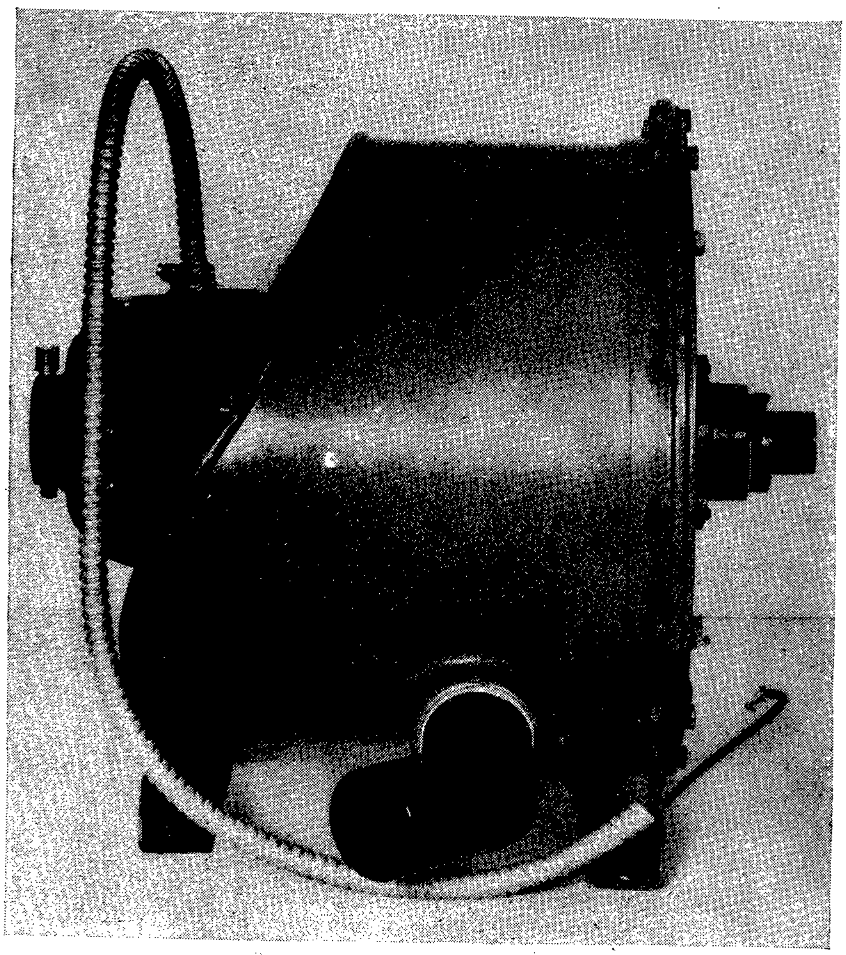


FIGURE 30.—Vacuum turbine.

(2) These jack screws consist of a large hexagon head bolt which screws down through a metal receptacle in the lower wooden platform. When the bolt is screwed in far enough it comes in contact with the floor and any further turning of the bolt will lift that corner of the base off the floor.

e. Autosyn pick-up assembly.—On models previous to the C–5 and C–3 not provided with the wind drift mechanism a bracket arrangement is provided, secured to the stationary portion of the main spindle, to support the Autosyn pick-up assembly which consists of an

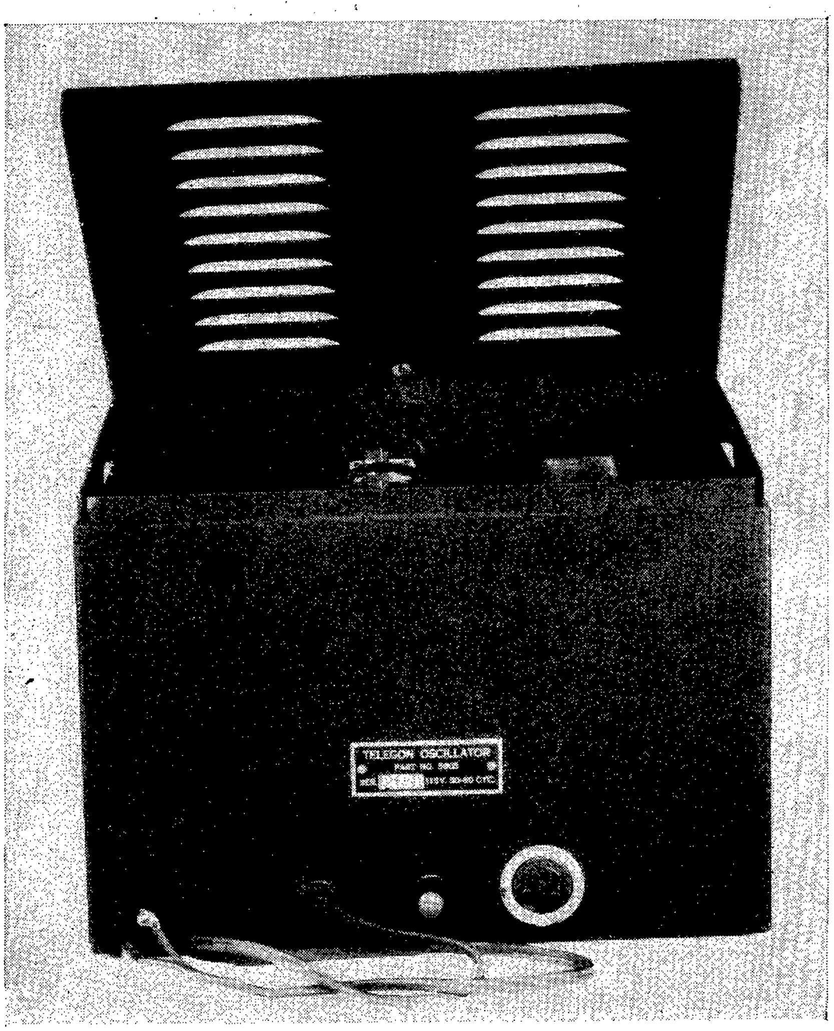


FIGURE 31.—Telegon oscillator.

Autosyn or Teletorque (on late models) unit, geared to the rotating part of the main spindle by a gear train. (See fig. 32.) This unit is connected electrically to the automatic recorder located at the desk,

and serves as the transmitter controlling the direction that the recorder travels. On models equipped with the wind drift device, this pick-up assembly is incorporated as part of the wind drift mechanism.

f. Wind drift device.—The wind drift device (fig. 28) serves to introduce the effects on trainer heading and ground speed of winds of

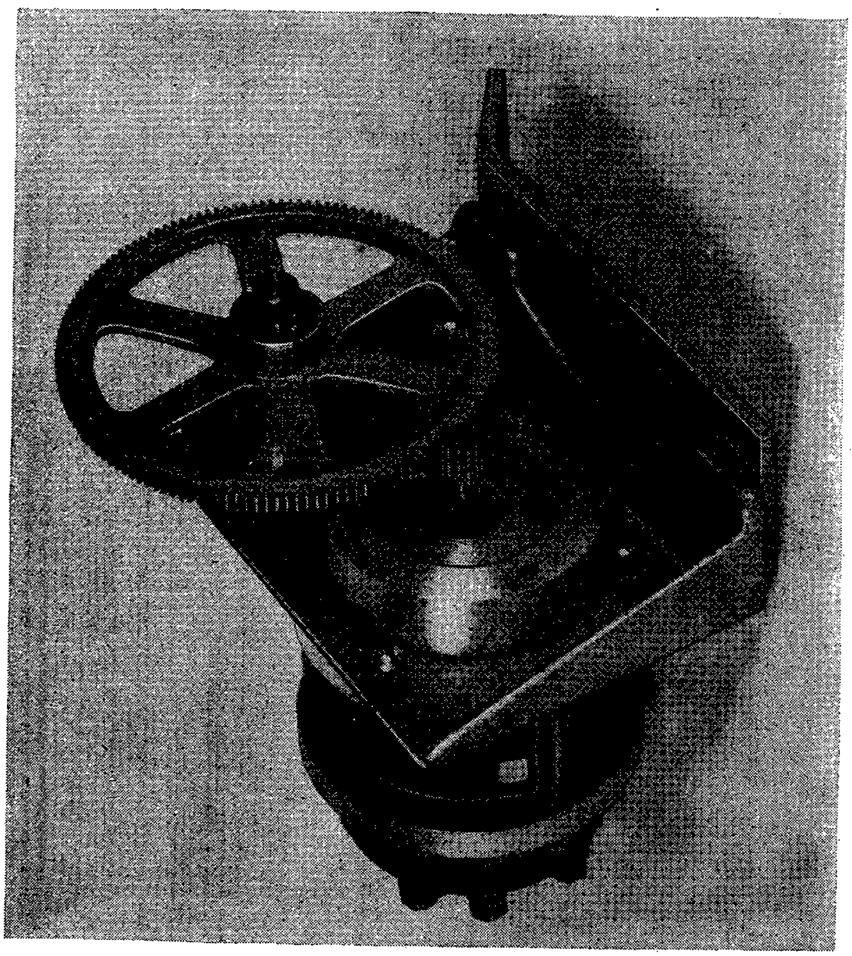


FIGURE 32.—Autosyn pick-up assembly.

varying velocities and from varying directions at cruising and other air speeds, as traced by the recorder, and consists of a large metal box mounted in base of the trainer on the lower platform diagonally across from the turbine. This box houses the wind drift device mechanism.

Attached to the wind drift box is the wind drift pick-up assembly which replaces the Autosyn pick-up assembly on trainers using the wind drift device. There are two flexible cables coming out of the wind drift box that go to two controls mounted on the instructor's desk. These controls and cables are provided so that the instructor may put any wind direction or any velocity, from 0 to 60 mph, into a problem.

g. Main spindle.—(1) The main spindle (fig. 33) is mounted on and supported by the iron cross of the base by four stud bolts, and extends from the base through the revolving octagon into and through the fuselage floor and serves as a means of transferring electrical cir-

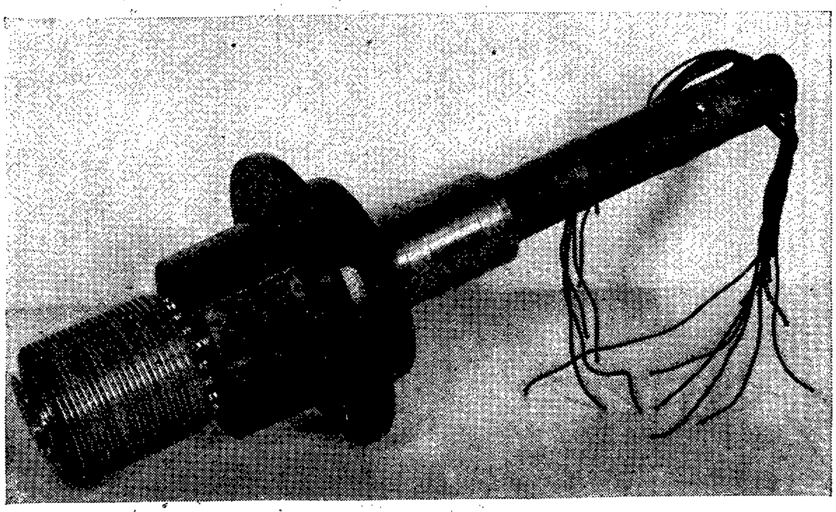


FIGURE 33.—Main spindle.

cuits, housing the main air transfer column and providing the means whereby the fuselage and octagon may be revolved through 360°.

(2) The fixed portion of the spindle houses the main bearings and main column that rotates with the fuselage. The portion extending through the main universal joint consists of the 2-inch black drill covered rubber hose of the air transfer system and the necessary wiring from base to fuselage.

(3) The bottom of the spindle terminates in the collector ring assembly and small ring gear that drives the Autosyn transmitter. Mounted on the same bracket that supports the Autosyn pick-up or wind drift pick-up assemblies is the brush assembly that serves the

collector ring consisting of two brass spring contacts for each collector ring.

h. Main air transfer elbow.—Serving as a means of transferring the flow of atmosphere from the spindle, which turns with the fuselage and octagon, to the vacuum turbine is the air transfer elbow. (See fig. 34.) It is a right angle elbow of steel construction held in place by a spring attached to the fixed part of the spindle and fitted into the bottom of the spindle by a machined, oil sealed, fit.

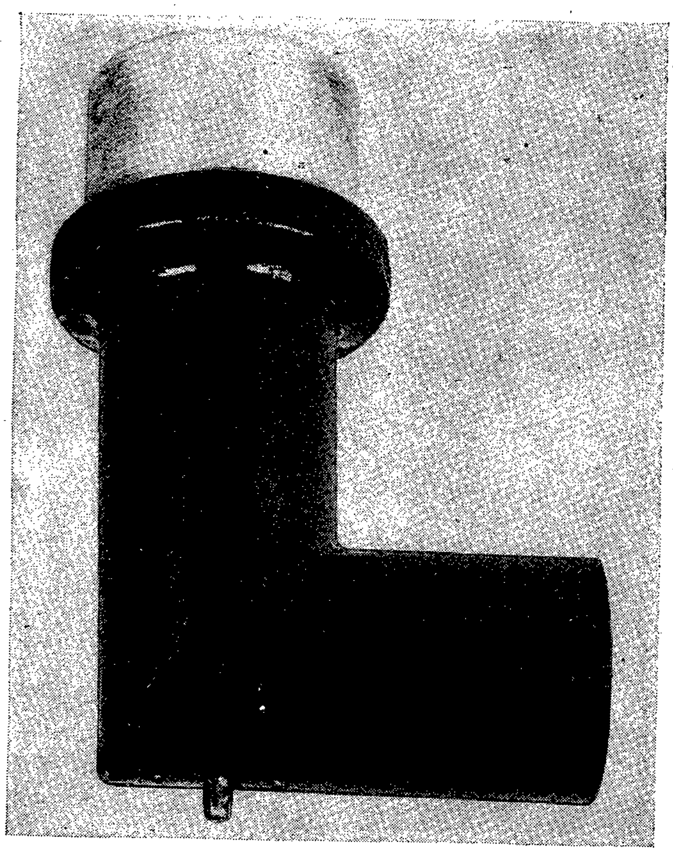


FIGURE 34.—Air transfer elbow.

i. Base iron cross.—The cast iron, iron cross of the base, similar in construction to the iron cross of the revolving octagon, is secured to the bottom side of the top base platform by large carriage bolts and supports the complete weight of the spindle, revolving octagon, and fuselage.

7. Desk.—The following units and subassemblies are located on or in the trainer desk (figs. 35 and 36):

a. Radio equipment.—(1) Located in the left-hand drawer of the trainer desk on models previous to the C-5 and C-3 models, is the radio simulating equipment. (See fig. 37.)

(2) This equipment consists of the radio chassis, the keyer mechanism, and the radio compass control box. Model C-4 (Special

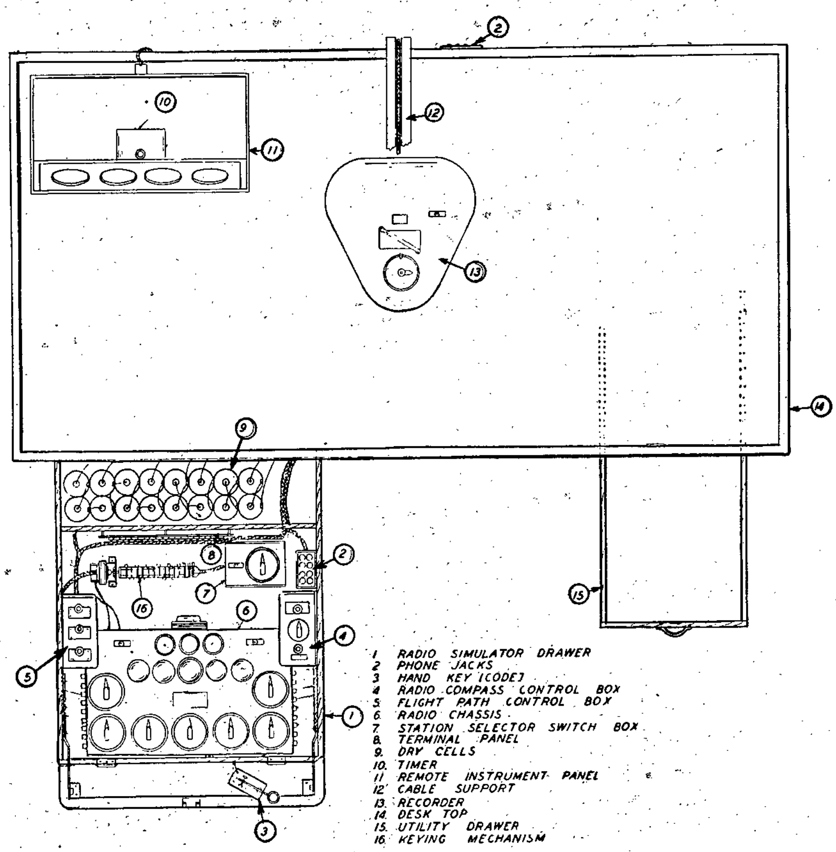


FIGURE 35.—Desk, C-4—top view.

E) also includes a flight path control box, but since this equipment is not used and is in no way standard it will not be covered further.

(3) The radio chassis includes the main rectifier, oscillator, and amplifier circuits as well as the various switches and rheostats necessary for their control, and the simulation of all signals common to the radio aids to navigation in use at the present time.

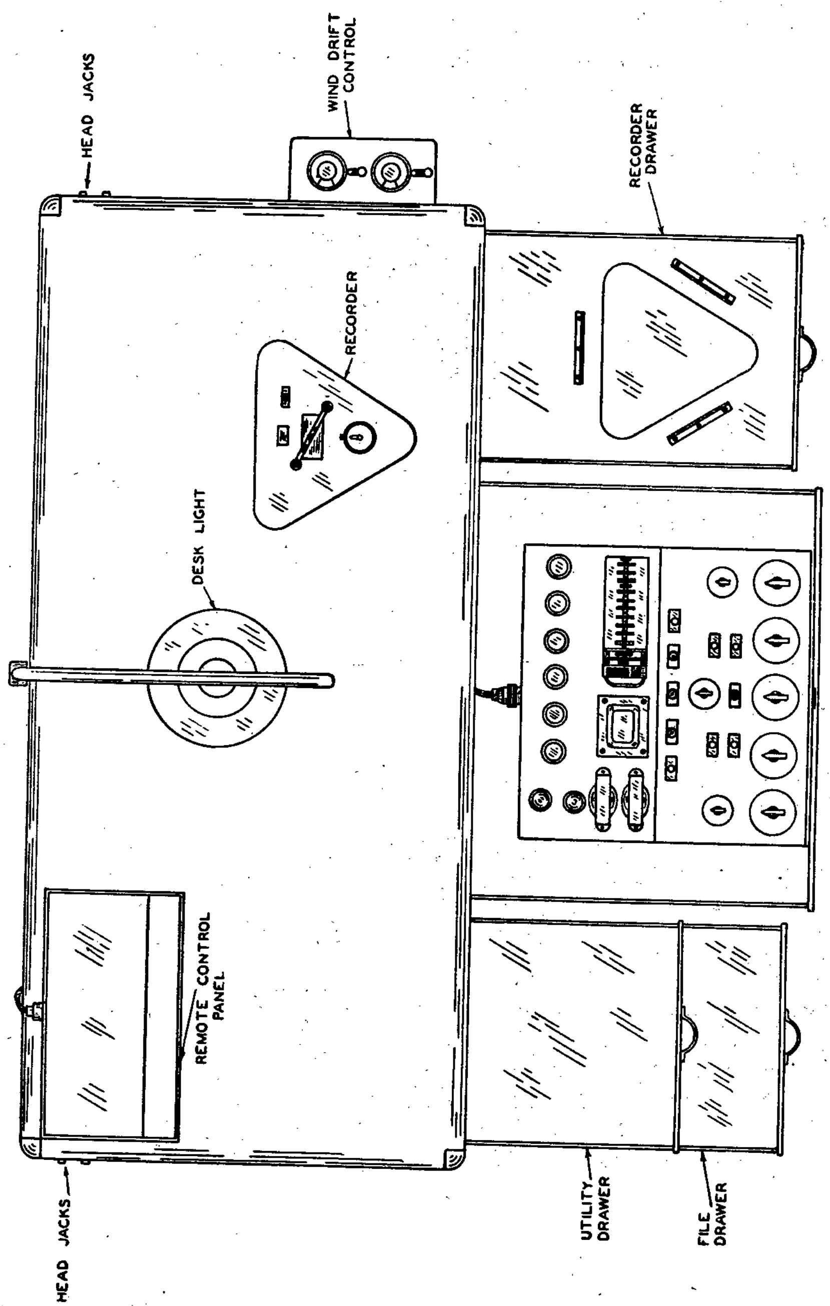


FIGURE 36.—Desk, C-3.

(4) The keyer mechanism (fig. 38), located directly behind the radio chassis, provides a means of keying the signals, by cam operated relays, so as to produce Morse code characters for simulation of radio ranges and marker beacons.

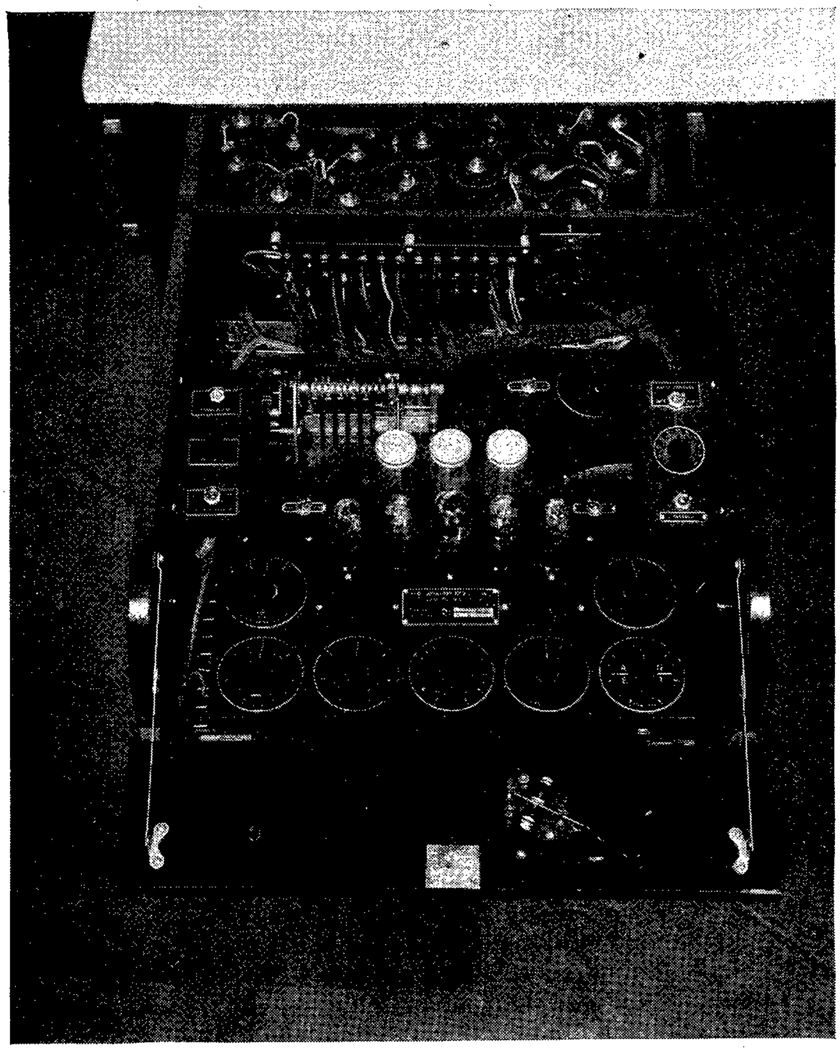


FIGURE 37.—Radio equipment, C-4.

(5) Mounted on the left-hand side of the desk drawer on C-2 trainers and the right-hand side on C-4 models, is the radio compass control box, which mounts the switches and rheostat of this system.

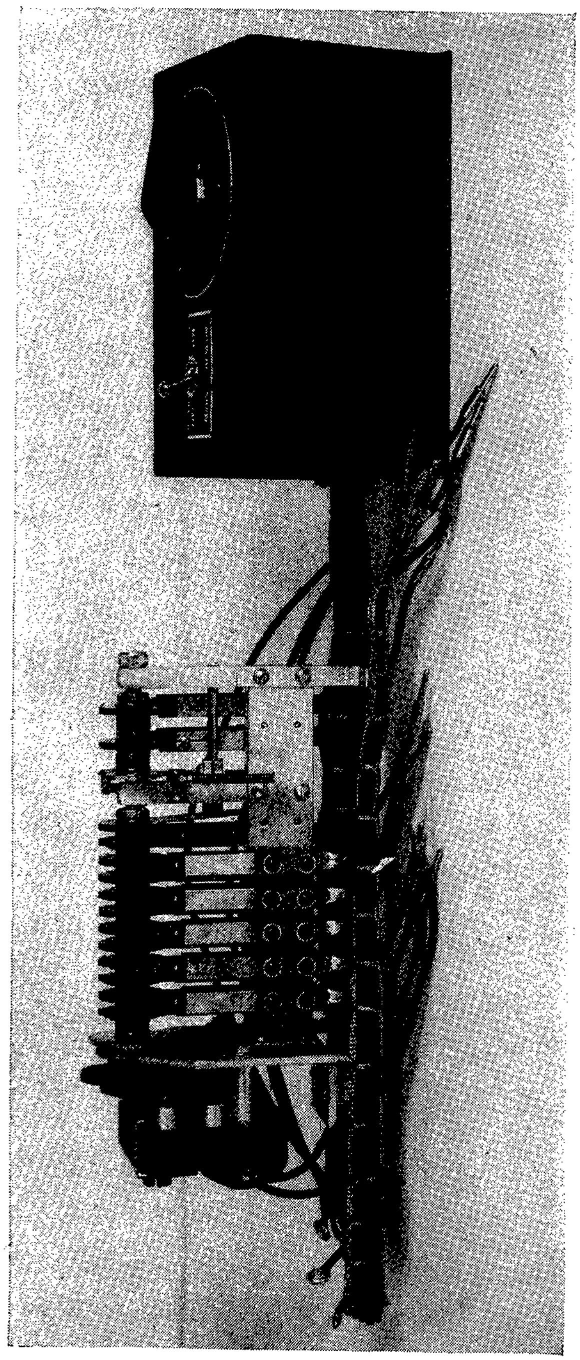


FIGURE 38.—Keyer mechanism.

An additional radio compass control is incorporated as part of the automatic recorder.

(6) Housed in a separate compartment in the rear of the drawer of C-2 and C-4 trainers are the dry batteries, 1½ volts each, necessary for the operation of the interphone circuit, the radio compass, and on Special E trainers the flight path system of instrument landings.

(7) Attached to the rear compartment partition on its front side is the terminal panel which serves as a junction for the interconnecting cable between desk and trainer, and the desk electrical equipment.

(8) The C-5 radio equipment located in the center drawer of the metal desk, common to C-5 and C-3 trainers, differs, primarily, from equipment standard with other models in that it is actual radio equipment instead of radio simulating equipment.

(9) Located in the extreme left rear corner of this drawer is the desk power supply unit, which furnishes the proper voltages for the other units employed. This type equipment employs two transmitters to facilitate problems run in the trainer where two or more stations are being simulated. These transmitters, consisting of four variable manual controls and a goniometer mounted on a metal case, which houses the electrical circuits necessary, are located one on each side of the drawer with the main control chassis and its associated controls—keyer, tubes, relays, etc., located in between the two transmitter units. All units being interconnected or connected into the desk junction box mounted on the rear drawer wall by cables and Jones plugs. The desk junction box serves in the same capacity as the older type electrical terminal panel.

(10) Closely associated with the radio equipment, standard in the C-5 model, is the loop antenna box (fig. 39). This unit is suspended by one of several means directly above the vertical axis of the trainer and since it contains the antenna system that radiates the radio waves to the receiving antennas in the fuselage hood, and since the accuracy of the radio compass depends upon the installation, it must be mounted correctly and in such a manner that it will not change position.

b. Remote instrument panel.—This unit (fig. 40) is normally located on top of the desk on the left rear corner, and serves as the mounting and housing for the three instruments common to the remote instrument (Telegon) system, air speed, altimeter, and vertical speed indicators; and on some models C-4 (Special E), the landing path indicator common to the Lorenz system of instrument landings.

c. Automatic recorder.—(1) The flight log or automatic recorder (fig. 41) is a device that follows the direction of the flight being made and records this flight graphically on a map or chart by means of an inked line.

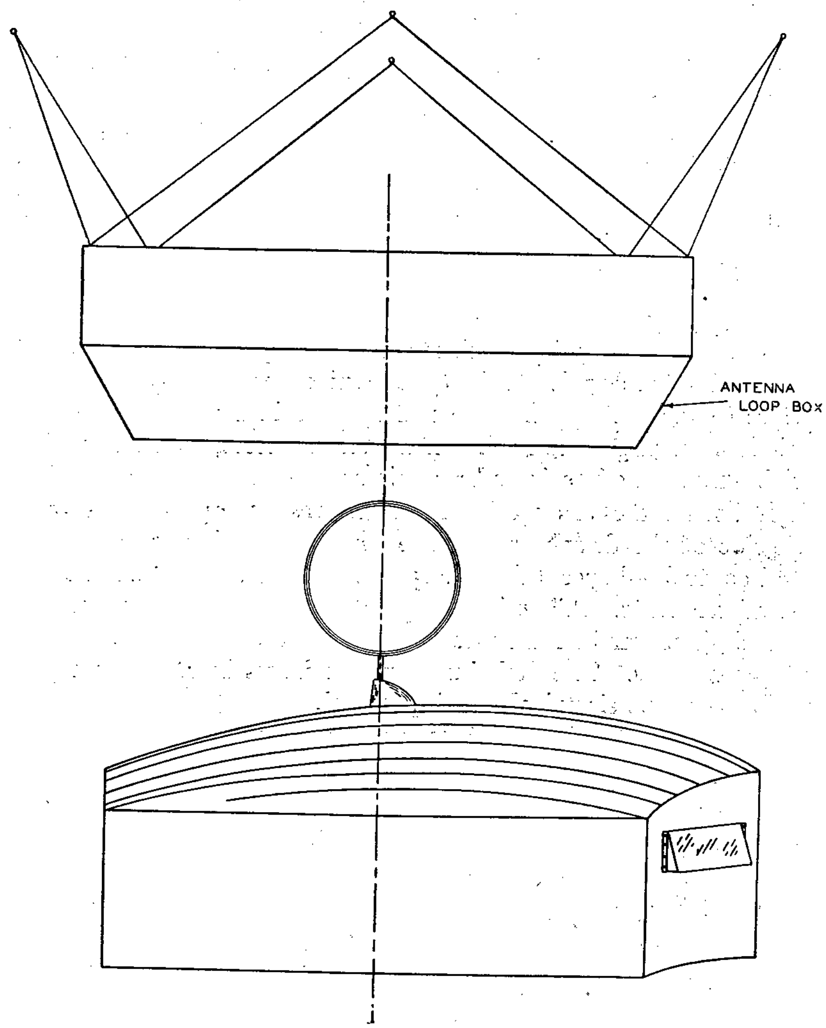


FIGURE 39.—Loop antenna box.

(2) On trainers equipped with the wind drift device, this recorder not only inks the line of flight, but inks the track or course made good, which may differ considerably from the course flown by the

student due to the effect of wind which has been introduced into the problem by the instructor.

(3) This device consists of a top plate with handle, mounting the radio compass visual indicator azimuth control, an on-off switch and the plug receptacle. This plate is supported by three spindles, two of which have the Telechon drive motors and wheel attached that serve to drive the recorder, and the other having the inking wheel and ink roller attached.

(4) Mounted in the center of this entire assembly and controlling through gear trains the direction of travel of recorder is the Autosyn or Teletorque receiver which, in turn, is controlled by the base Autosyn or Teletorque transmitter on the wind drift mechanism on trainers so equipped.

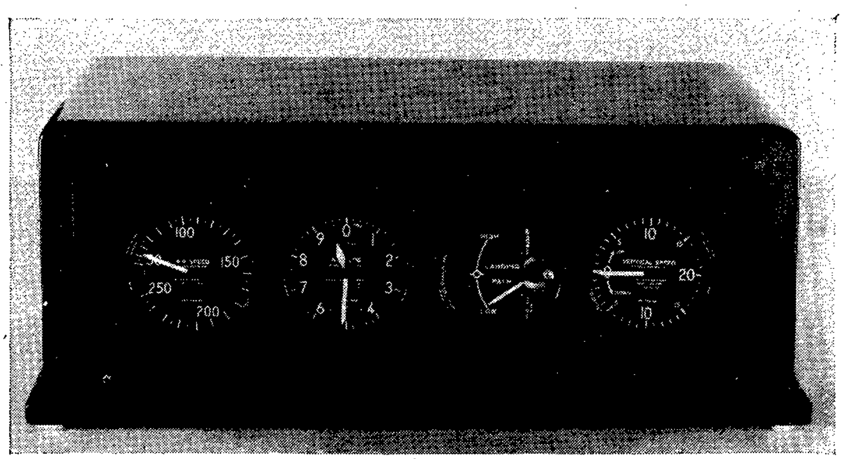


FIGURE 40.—Remote instrument panel.

(5) When in use this unit is placed on the chart or paper that is secured to the desk top and moves over that chart in accordance with the flight of the trainer. When not in use the recorder is kept in a special box constructed so as to hold the recorder without damage. On C-5 and C-3 trainers a drawer of the steel desk is allotted for its storage.

d. Cable and light support.—The fixture which supports the lamp over the trainer desk (fig. 36) and also carries the recorder cable is bolted to the back of the desk as standard equipment on C-5 and C-3 trainers. A device of local manufacture may be installed on the older type wooden desk to serve as a recorder cable support if desired. This unit is nothing more than an upright with right angle

braced arm made of wood, channeled for the recorder cable. Use of these supports replaces the old method of suspending the recorder cable, by cord, chain, or cable from the ceiling of the trainer room which under some circumstances proved impractical if not impossible.

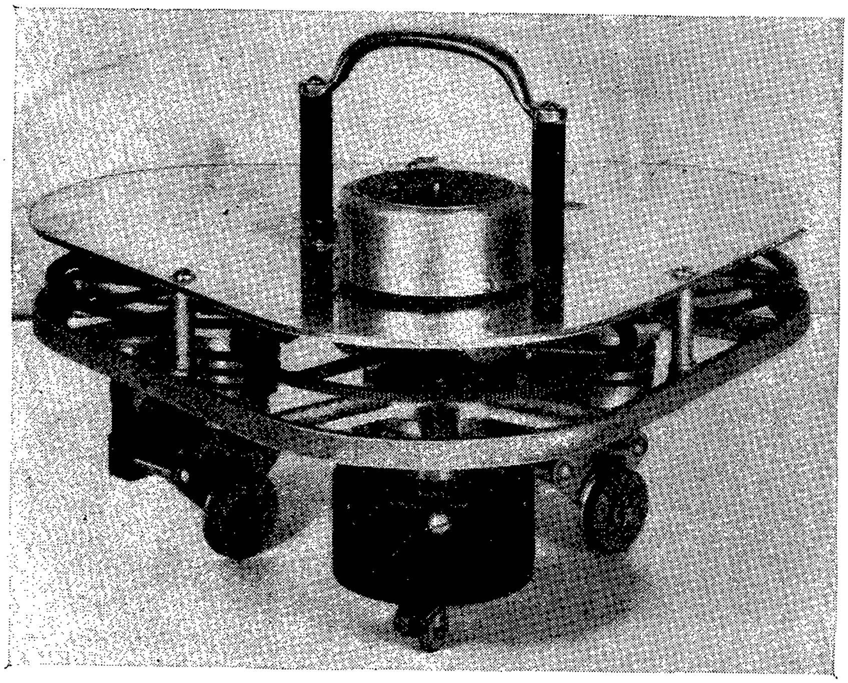


FIGURE 41.—Automatic recorder.

SECTION III

PRINCIPLES OF OPERATION

8. General.—All trainers referred to in this manual utilize three basic principles of operation—vacuum, mechanical, and electrical. Although these princples are interconnected and interwoven in the trainer operation, they will be dealt with in this section individually so far as possible and practicable.

9. Vacuum operation.—*a. General.*—(1) A vacuum is, theoretically, a portion or region of space entirely empty of matter. Prac-

tically it is impossible to create a complete vacuum so it may be said that a vacuum is a space, such as the inside of an incandescent light bulb, nearly emptied of air and gases by artificial means.

(2) The trainer is operated in part by a partial vacuum, supplied by the ¾-horsepower electric-driven turbine located in the trainer base. This is a partial vacuum at all times, and its extent is controlled by the various valves incorporated in the trainer. For instructional purposes the *difference between outside normal atmosphere pressure and the pressure existing inside of a given part will be referred to as "pressure differential."* The effect of evacuating part of the air of a container is to reduce the pressure inside the container.

(3) Normal atmospheric pressure at sea level is 14.7 pounds per square inch or, if measured with a manometer, 29.92 inches of mercury. We are so accustomed to living in this pressure of air that we forget there is any pressure. If any of the air from a container is evacuated, a pressure differential exists between the inside and outside of that container. The pressure on the outside will be greater than the pressure inside and will try to crush that container. This is just what happens when the air is partially evacuated from a bellows. Outside pressure crushes that bellows and in crushing it moves the linkage or part to which it is attached. When some of the air is removed from the inside, the air on the outside pushes the bellows together. If a tank is used instead of a bellows, a gage is more readily attached and the pressure inside measured as compared to outside pressure. If the tank is evacuated to the extent of having 10.7 pounds inside while having 14.7 pounds outside the gage would show the difference, 4 pounds pressure differental.

(4) One means of measuring the degree of vacuum is with a mercury gage (manometer). This is a **U**-shaped glass tube, with the open ends up, filled a little less than half full with mercury. With a rubber tube attached to one of the open ends of the glass and the other end of this tube connected to a tank, the height the mercury is displaced will indicate the degree of vacuum existing inside that tank. The difference in height between the two columns of mercury in the **U**-shaped glass is measured in inches and the indication read as "inches of mercury." It takes roughly 1 pound of pressure differential to give an indication of 2 inches of mercury or 2Hg.

(5) Another means of measuring a vacuum supply is a suction gage. The operating principle of this instrument, which is common to all airplanes in the gyroscopic instrument lines, is a pressure cap-

sule which expands or contracts in proportion to the amount of vacuum applied to it and in so doing moves, by linkage and gears, an indicator across a calibrated scale which may be in inches of mercury or pounds per square inch.

(6) As an aid to the complete understanding of any vacuum system, remember always that vacuum does not flow; rather it is a flow of atmosphere to the source of vacuum which is produced in a system of application of a means of creating a vacuum. This means may utilize one of several different principles, the rotary impeller, the engine or motor-driven pump, or the high speed flow of atmosphere by an orifice. The most common means of producing vacuum are the vacuum pump, the vacuum turbine, and the Venturi tube (fig. 42).

(7) The high speed vacuum turbine is the source of supply for all vacuum systems utilized in the trainer. This turbine has a capacity of approximately 12 cubic feet of air per minute at a pressure differential of 4 inches of mercury (Hg).

b. Complete vacuum system.—The complete vacuum system (fig. 43) of the trainer utilizes both metallic and rubber composition conductors of various sizes, several different types of valves, instruments, and bellows. The following is a general explanation of the complete vacuum system followed by a break-down of the complete system into the various subsystems.

(1) The vacuum turbine located in the base is connected into the main air transfer column of the spindle by the air transfer elbow and 2-inch black drill covered hose. Some installations permit the removal of the turbine from the base to a position outside of the trainer room, thereby eliminating the noise and heat generated by this unit.

(2) Connected to the top of the air transfer column is the air transfer manifold elbow having the first vacuum supply take-offs mounted on it. On one side, the four leads connecting into the climb-dive valves, the air speed system, the tachometer system, and the spin valve; on the other side, a single take-off for the operation of the two gyroscopic instruments.

(3) Connected to the manifold elbow by hose and hose clamps is the main air transfer manifold, on one end of which is the connection to the rudder valve which controls the application of vacuum to the right and left banks of the turning motor through hose lines and also controls the application of the vacuum supply to the front pitching bellows and the venting to atmosphere of the rear pitching bellows of the automatic nose drop system.

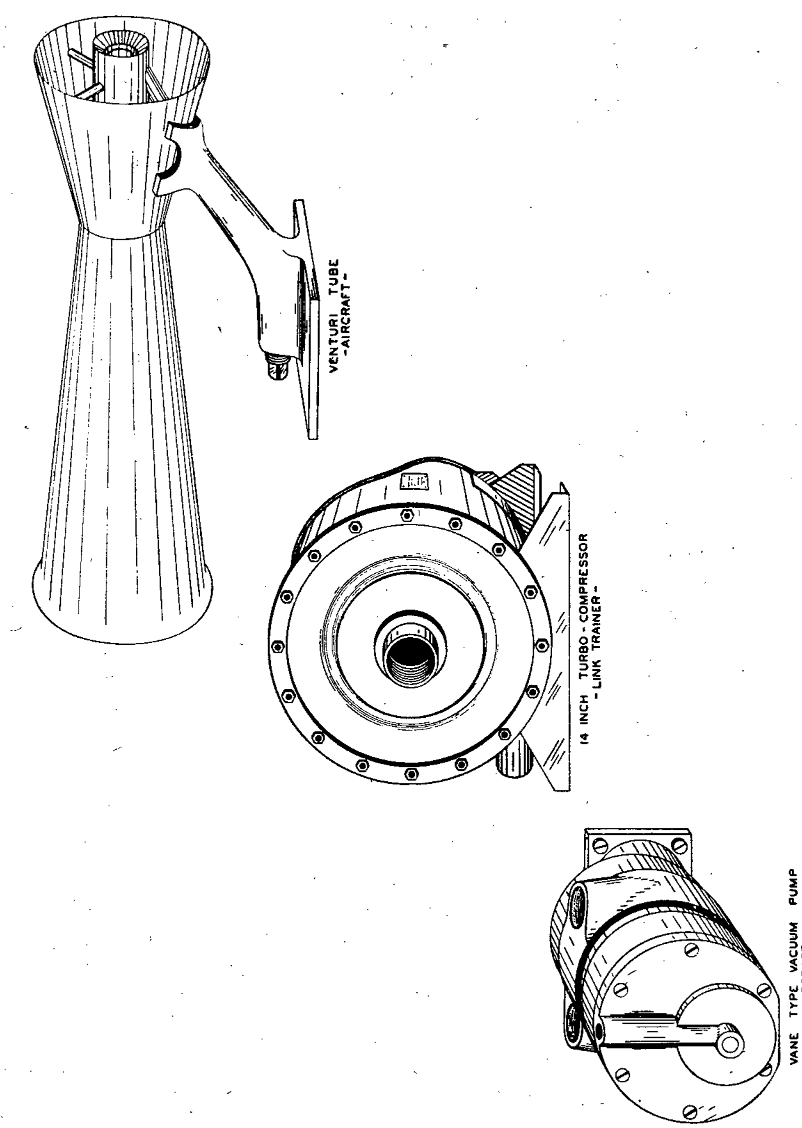


FIGURE 42.—Means of creating vacuum.

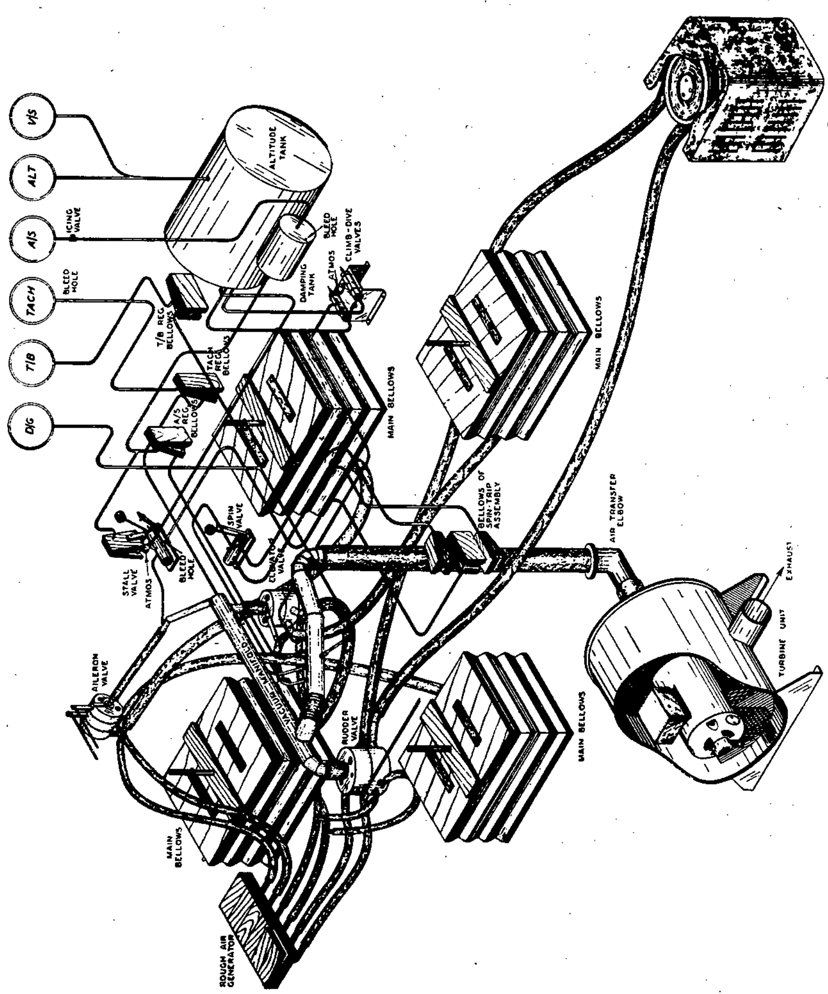


FIGURE 43.—Complete trainer vacuum system.

(4) A second take-off from the main manifold supplies the elevator valve with a source of vacuum. This valve controls the application of vacuum to the fore and aft main bellows, for normal pitching action, through hose connections directly to the base of the bellows.

(5) The third connection from the manifold connects to the aileron valve which in turn controls the application of vacuum to the right and left banking bellows through hose connections to the base of these bellows.

(6) The fourth take-off from the manifold supplies the stall valve which controls the application of vacuum to the center bellows of the spin-trip assembly and also when actuated by its bellows vents the altitude system to the atmosphere through the line leading direct to the altitude tank.

(7) The climb-dive valves are connected by hose connections and metal line to the altitude tank, the spin valve to the top and bottom bellows of the spin-trip assembly, and the vertical speed indicator and altimeter to the altitude tank.

(8) The air speed indicator is connected by lines to the air speed damping tank, the tank to the regulator bellows, and the bellows to the source of vacuum supply. In the line between the air speed tank and the regulator bellows there is a lead running to the stall valve actuating bellows.

(9) The tachometer system comprises the instrument, attached by line to the tachometer regulator bellows, which is attached to the source of supply. Located in the line between the regulator bellows and the tachometer is a bleed hole of .025-inch.

(10) The rough air mechanism flap valves are connected by rubber tubing to the lines leading from the three main control valves, with the extra leads from the rudder valve for automatic nose drop, connecting by a metal T-tube, into the rough air leads of the pitching bellows.

c. Details of subsystems.—The following subparagraphs deal with the details of the various individual vacuum systems that compose the complete vacuum system:

(1) *Main, attitude and direction, control system.*—(*a*) The attitude of an airplane or trainer has been defined as the position of an aircraft as determined by the inclination of its axes to some plane of reference. If not otherwise specified, this plane of reference is fixed to the earth.

(*b*) The direction of an airplane or trainer may be defined as the azimuth bearing of the longitudinal axis with respect to true north.

(*c*) Attitude control, movement of the trainer about its longitudinal and lateral axes, is accomplished by the partial evacuation of the atmosphere from the banking and pitching bellows controlled by movement of the top sections of the aileron and elevator valves (fig. 44).

(*d*) As soon as the vacuum turbine is energized and reaches its working rpm a vacuum supply is applied to the valve spindle, through its connection to the main air transfer manifold, and a small amount of atmosphere is evacuated from the bellows to which

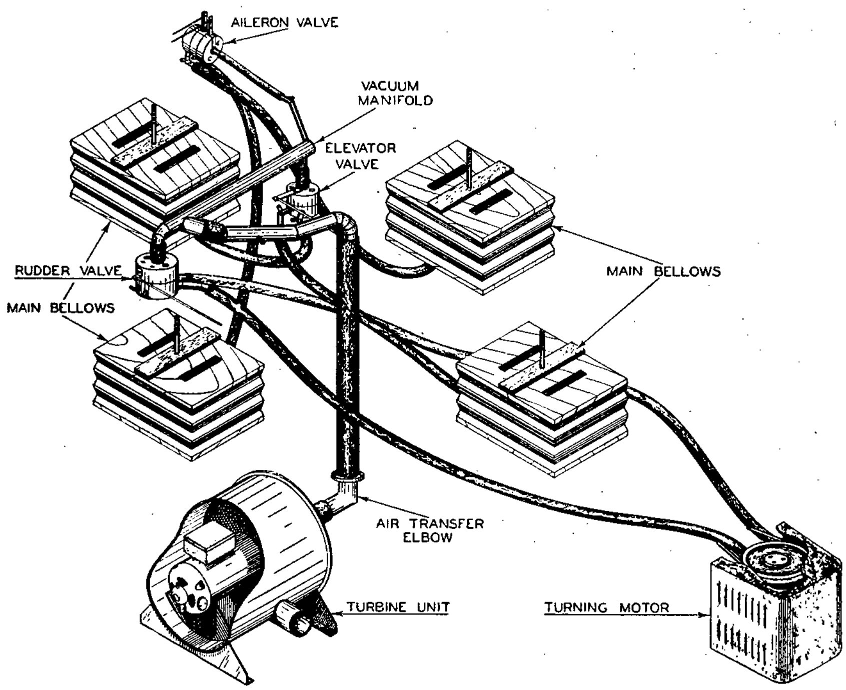


FIGURE 44.—Attitude and directional control system (vacuum).

the valve is connected due to the construction of the valve which provides for a small overlap of the exhaust ports, of the top and bottom sections, when the valve is in a neutral position. This condition is necessary so that a constant equal pressure differential will exist in both bellows of a pair when the valve is neutralized in order to hold one particular trainer attitude. When by movement of the manual controls, the top half of the elevator valve is moved, the valve vents one of the pitching bellows to atmosphere at the valve and the other to the vacuum supply. The bellows vented to

the vacuum supply is compressed due to the pressure of the outside atmosphere and the bellows vented to atmosphere is permitted to expand. Due to the fact that these bellows are linked to the fuselage the fuselage will be declined or pitched in the direction of the compressed bellows. When the desired angle of pitch is reached, the valve is neutralized by the pilot and supplies both bellows with an equal amount of vacuum and so maintains that attitude.

(*e*) The means employed by the banking system, for movement about the longitudinal axis, is essentially the same except for an added feature which simulates the tendency of most airplanes to bank when yawing or when turning movement takes place. The center leaf of the aileron valve performs this function by venting one of the banking bellows to the vacuum supply and the other to atmosphere whenever movement of the rudder valve, which controls turning motion, takes place.

(*f*) The rudder system is composed of the rudder valve, a valve of slightly larger proportions and different construction, attached by its hollow spindle to the manifold by rubber hose and hose clamps, the two long hose leads, and the turning motor itself. This valve also provides for a small overlap in ports, permitting a constant application of vacuum to the hose connections when the valve is in a neutral position.

(*g*) The turning motor is actually two separate motors geared to one pulley. When the top half of the rudder valve is rotated, due to rudder bar action, one bank of the motor is vented to atmosphere at the valve and the other bank is vented to the vacuum supply through ports in the valve, and turns the trainer. The other bank simply idles and follows because of the interconnecting gears.

(*h*) The nose drop feature built into the rudder valve is incorporated to simulate another natural tendency of an airplane; that is, an airplane's nose tends to drop whenever a turn is made. This tendency is simulated by additional ports in the rudder valve that applies the vacuum supply to the front pitching bellows and vents the rear pitching bellows to atmosphere whenever the top half of the rudder valve is rotated. The additional lines necessary for this feature are connected, from the rudder valve, directly into the rough air lines by T-connections which are in turn connected into the main leads to the front and rear pitching bellows.

(2) *Altitude system.*—(*a*) The altitude vacuum system (fig. 45) is merely a means of creating a pressure differential, controlling and measuring it. The vertical speed indicator measures the *rate of change* in the pressure differential created in the altitude or climb-

dive tank as it is sometimes known, and the altimeter is the means of measuring the *amount* of pressure differential. The altitude tank is connected to the source of vacuum through the climb valve, a part of the climb-dive valve assembly which in turn is controlled by changes in the trainer's attitude and throttle setting.

(*b*) As the throttle is opened or the trainer nosed up, the climb valve is opened and the dive valve closed, thus venting the altitude

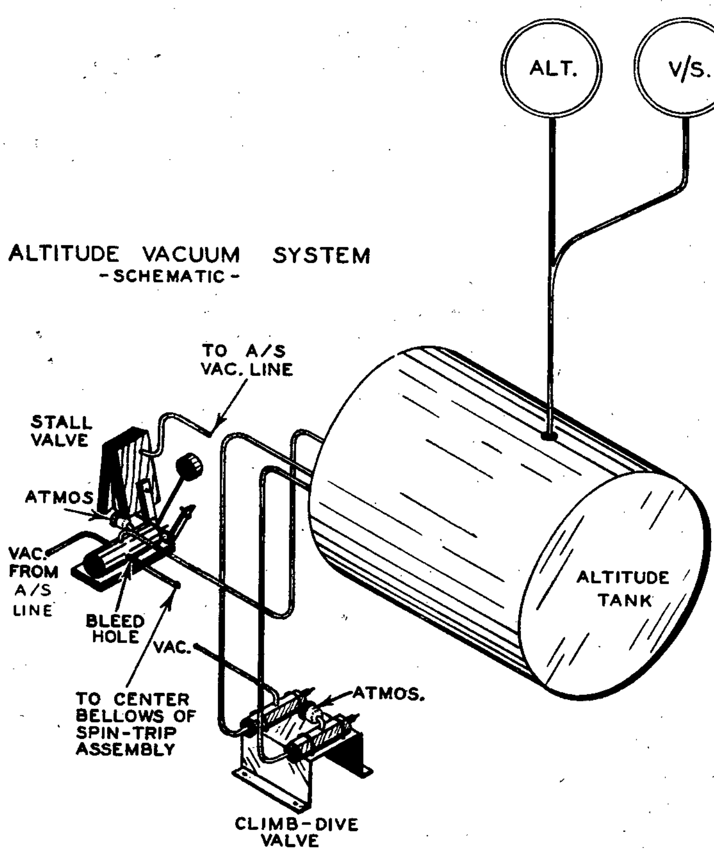


FIGURE 45.—Altitude vacuum system.

tank to the source of vacuum and partially evacuating it. As soon as the atmosphere starts to flow from the tank, the rate at which it is flowing is indicated on the vertical speed indicator as a rate of climb and the amount being evacuated is indicated by the altimeter as "Altitude." When the desired altitude is reached the throttle is neutralized or the trainer leveled off which closes both the climb and

dive valves and so seals the altitude system whereon the vertical speed indicator will zero, since no change in altitude is taking place, and the indicated altitude on the altimeter will remain constant. When the throttle is closed or the trainer nosed down, the climb valve is held closed and the dive valve opened which vents the altitude system to atmosphere at the dive valve. When the atmosphere enters the system a rate of descent is shown and the altitude decreases.

(*c*) The altitude system also includes a portion of the stall valve assembly which is connected into the system and is the means of venting the system to atmosphere when the air speed is sufficiently low and the "mush" or loss of altitude must be shown to simulate an actual airplane's mushing tendencies.

(3) *Air speed system.*—(*a*) The air speed system (fig. 46) is designed to actuate the trainer air speed indicator in a manner that

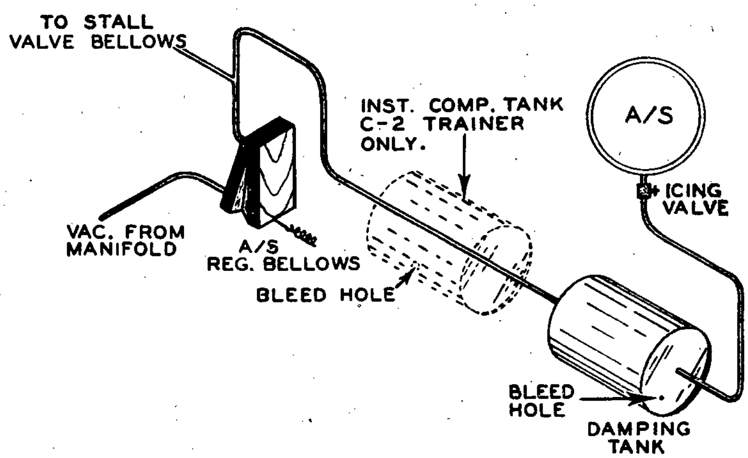


FIGURE 46.—Air speed vacuum system.

simulates the action of such an indicator in an airplane. This is accomplished by the throttle assembly and linkage from the pitch action assembly to an instrument through a regulator bellows, tubing, and damping tank.

(*b*) When the regulator bellows is expanded due to throttle or pitching action it opens a valve inside the bellows and permits the partial evacuation of that system, through the tubing and tank, and an indication of a raise in indicated air speed. When the application of the vacuum supply is removed, the indication is reversed due to atmosphere entering the system through the bleed hole in the damping tank. The damping tank is included to furnish, as its name implies, a certain amount of damping or lag of the indications on

the meter. In addition to the tank a capillary tube of .018 inch diameter is located in the air speed line at the instrument to further dampen the action of the indicator.

(*c*) Since an airplane does not accelerate or decelerate quickly, but requires a small amount of time to overcome its inertia, it is necessary that these units be included in the air speed system to more accurately simulate the movement of such an instrument in an airplane; if they were not, the indications would change too rapidly and would tend to be jerky.

(*d*) The mechanical operation of the stall valve assembly is dependent upon its actuating bellows which is connected into the air speed system in such a manner that when the pressure differential in that line becomes high, the stall valve bellows will be collapsed and when it is low, or zero, the bellows will be expanded, so actuating the stall valve assembly.

(4) *Tachometer system.*—(*a*) The tachometer vacuum system (fig. 47) is similar to the air speed system and is designed to give an indicated change in revolutions per minute, of the simulated engine crankshaft, due to a change of throttle setting or attitude.

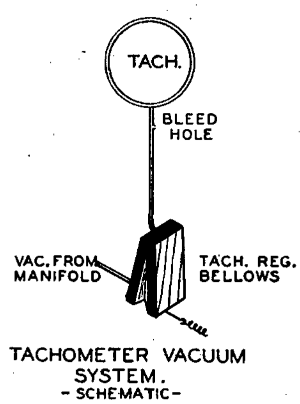


FIGURE 47.—Tachometer vacuum system.

(*b*) This system employs a regulator bellows in its line, which is controlled by linkage from the throttle and pitch action assembly, and in turn controls the application of the source of vacuum to the indicator through its tubing. The indicator itself is of the same construction as the air speed indicator, it being an instrument employing a diaphram to measure the amount of pressure differential existing in the line to which it is attached. Calibration on the air speed indicator is in miles per hour, and that of the tachometer in revolutions

per minute. Since changes in rpm take place much quicker than changes in air speed, a damping tank is not necessary. However, a capillary tube of 0.018 inch, inside diameter, is provided in the line at the instrument and a bleed hole is located in the line to give a small damping effect and to permit the instrument to fall off when the application of vacuum is decreased or stopped by the partial or complete closing of the regulator bellows.

(5) *Automatic spin system.*—(*a*) This system (fig. 48) is incorporated in the trainer for the purpose of creating instrument indications parallel to those of an actual airplane in a spin.

(*b*) The immediate cause for a spin is the lack of flying speed. This is evidenced in a trainer, as well as in an airplane, by the indications of the air speed indicator and the vertical speed indicator. When the air speed falls below a certain predetermined figure, the stall valve bellows is vented to atmosphere through the bleed hole in the air speed system and expands. When this bellows expands it actuates, through linkage, the stall valve, vents the altitude system to atmosphere at the valve and the center bellows of the spin-trip assembly to vacuum, thereby causing it to collapse and unlock that assembly from its associated assembly, the bank turner.

(*c*) The spin valve, connected to the vacuum supply by rubber and metal tubing and to the upper and lower bellows of the spin-trip assembly, is of such internal construction that either the upper or lower bellows is vented to vacuum and the other is vented to atmosphere at the valve. When the center bellows is collapsed and unlocks the assembly, it rotates about its torque rod and in so doing moves the top half of the rudder valve, venting one of the turning motor banks to the vacuum supply, thus causing rotation of the trainer about its vertical axis simulating the turning of an airplane in a spin.

(6) *Rough air system.*—(*a*) The rough air motor or generator consists of six cam-operated flap valves which are connected into the lines leading to the banking and pitching bellows and to the two banks of the air turning motor. (See fig. 49.)

(*b*) When the trainer is flying in a level attitude, both banking and both pitching bellows are vented to the same amount of vacuum and both bellows are compressed equally. When one of a pair of the rough air flap valves is opened by its cam, a leak is introduced in the main bellows to which the valve is connected. This weakens the pull of that bellows and allows the opposite bellows to pull one side or end of the fuselage down. Thus a lateral or a pitching bump occurs whenever the corresponding rough air flap valve is opened. Bumps affecting the movement of the trainer about its vertical axis are ar-

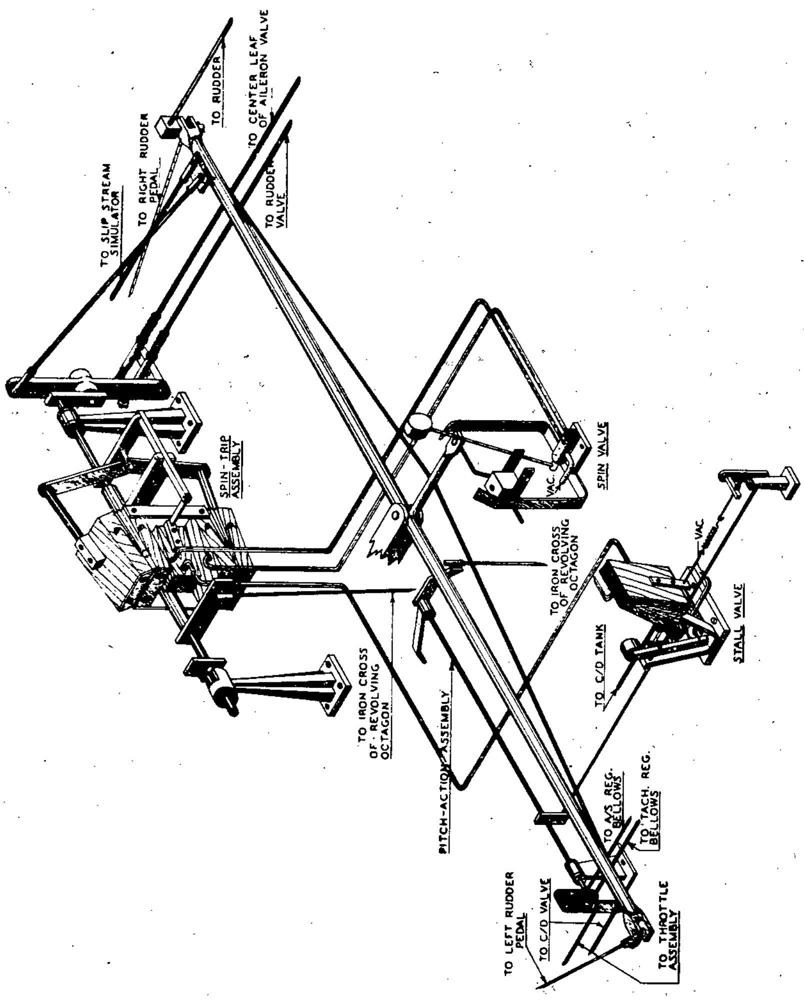


FIGURE 48.—Automatic spin system.

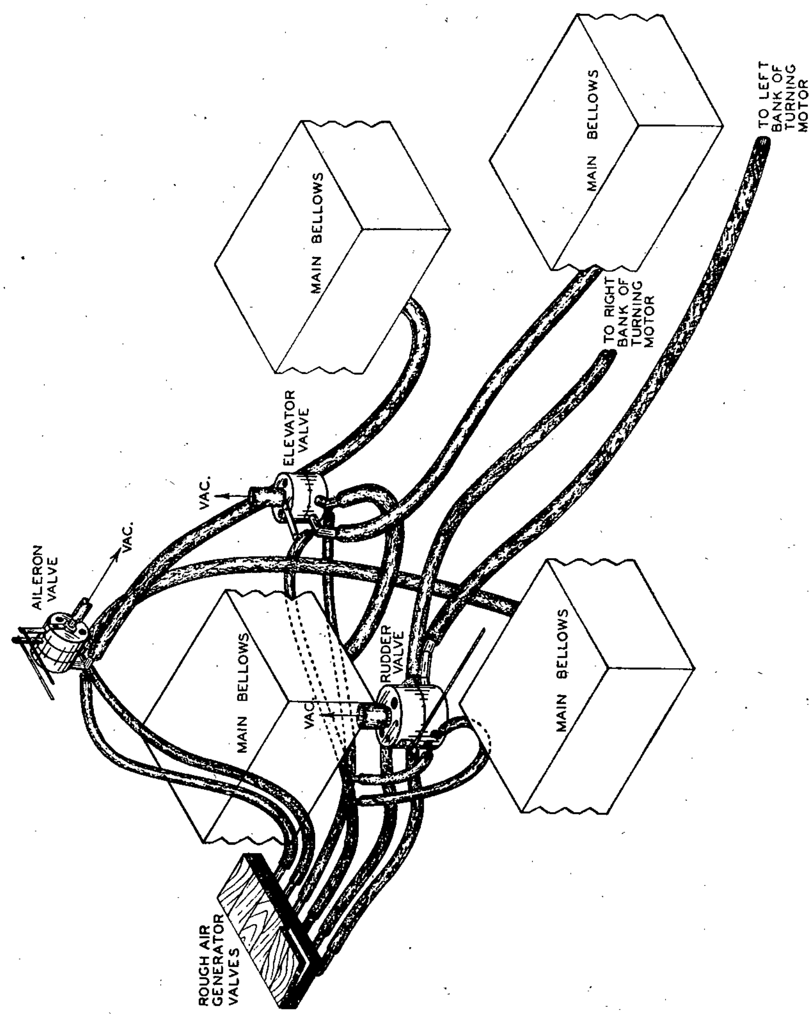


FIGURE 49.—Rough air system.

rived at differently. Due to the overlap built into the valves, a small amount of vacuum is constantly applied to the tubes leading to the turning motor when the valve is neutralized. This vacuum is normally allowed to escape through the rough air flap valves which are ordinarily held open. When one of these valves is allowed to close, the vacuum that has been escaping is applied to one bank of the turning motor causing it to turn.

(*c*) The cams that operate the rough air motor are so adjusted that they operate the flap valves, one at a time on each set of two, so that, in the case of the pitching and banking valves, they cause a momentary leak of atmosphere into the system to which they are connected, and in the case of the turning bumps, they shut off a constant leak momentarily.

10. Mechanical operation.—This system may be subdivided into two separate systems: the trainer attitude control and the instrument control.

a. Attitude and directional control system.—(1) Attitude and directional control of the trainer is obtained in the same manner as in an airplane, by use of the three controls: rudder, aileron, and elevator. Maneuvers can be performed in the trainer in excess of maneuvers normally performed on instruments in an airplane.

(2) In addition to the three manual controls there are three automatic features built into the trainer that affect the trainer attitude and further simulate the inherent characteristics of an airplane in flight. These features are automatic bank, automatic turn, and automatic nose drop.

NOTE.—The trainer attitude is also affected by the rough air generator when that mechanism is turned on.

(3) The rudder control consists of two pedals mounted in the nose of the trainer on the fuselage floor connected by steel cable to the two ends of the rudder bar which is mounted under the pilot's seat and is pivoted in the center on the longitudinal axis. At the rudder bar end of the left rudder cable is a safety link. This safety link is provided to prevent damage to the rudder control system due to excessive, violent movement of rudder pedals. The rudder is operated by the feet, the pedals being mounted one on the left and one on the right of the longitudinal axis within easy reach of the pilot. The rudder bar is connected by a link rod on the extreme right end to the top end of the walking beam of the spin-trip assembly. The lower end of the walking beam is connected by spring compensator link rod, to the top half of the rudder valve. Any movement of the rudder

pedals will cause a movement of the top half of the rudder valve and will result in a turning or yawing motion of the trainer.

(4) Attached to the rudder bar in the center and extending toward the rear of the trainer is a fork arrangement. This fork arrangement is so constructed that when either right or left rudder is applied, the spin valve is actuated. (See fig. 50.)

(5) The aileron control may utilize one of two systems, stick or wheel control. When stick control is used, the system consists of a stick positioned on the longitudinal axis and mounted on the aileron torque shaft vertical arm. It is fastened to the vertical arm at the top, at a single point, and extends to a point below the torque shaft. This system of mounting the stick makes possible elevator control which will be discussed later. The vertical arm of the torque shaft is mounted rigidly to the torque shaft. Lateral movement of the stick results in a rotary movement of the torque shaft which lies along the longitudinal axis, and is held in place by two metal brackets in which it is free to turn. On the rear end of the torque shaft is mounted a lever arm to which is attached the link rod that actuates the aileron valve. It may be seen by reference to figure 50 that lateral movement of the stick results in rotary movement of the upper leaf of the aileron valve, which will cause the trainer to bank in the direction of control movement.

(6) When wheel control is used, the system consists of the wheel mounted on the elevator control column, with a gear and pulley arrangement within the control column shell. (See fig. 51.) A small gear is mounted on the aileron control wheel shaft and meshes with a larger gear to which is fastened a pulley. Fastened to the pulley is a steel cable which is in turn fastened at the lower end around another pulley attached to the aileron torque shaft. Due to the control wheel movement being reversed by the gear arrangement at the top, it is necessary to reverse the movement by crossing the steel cable between the two pulleys. The gear ratio at the top serves to reduce the movement of the wheel in the correct proportion, so that aileron control of the trainer will closely simulate that of an airplane. By referring to figure 51 it may be seen that rotary movement of the wheel will result in a like movement of the top half aileron valve and will result in a bank in the direction of control movement.

(7) Aileron control of the C–3 type trainer differs from the two systems already mentioned in that the C–3 trainer has what is known as "Interchangeable stick and wheel control" system (fig. 52). This system consists of the main or base unit which is constructed to receive either the wheel or the stick; that is, the wheel control unit or

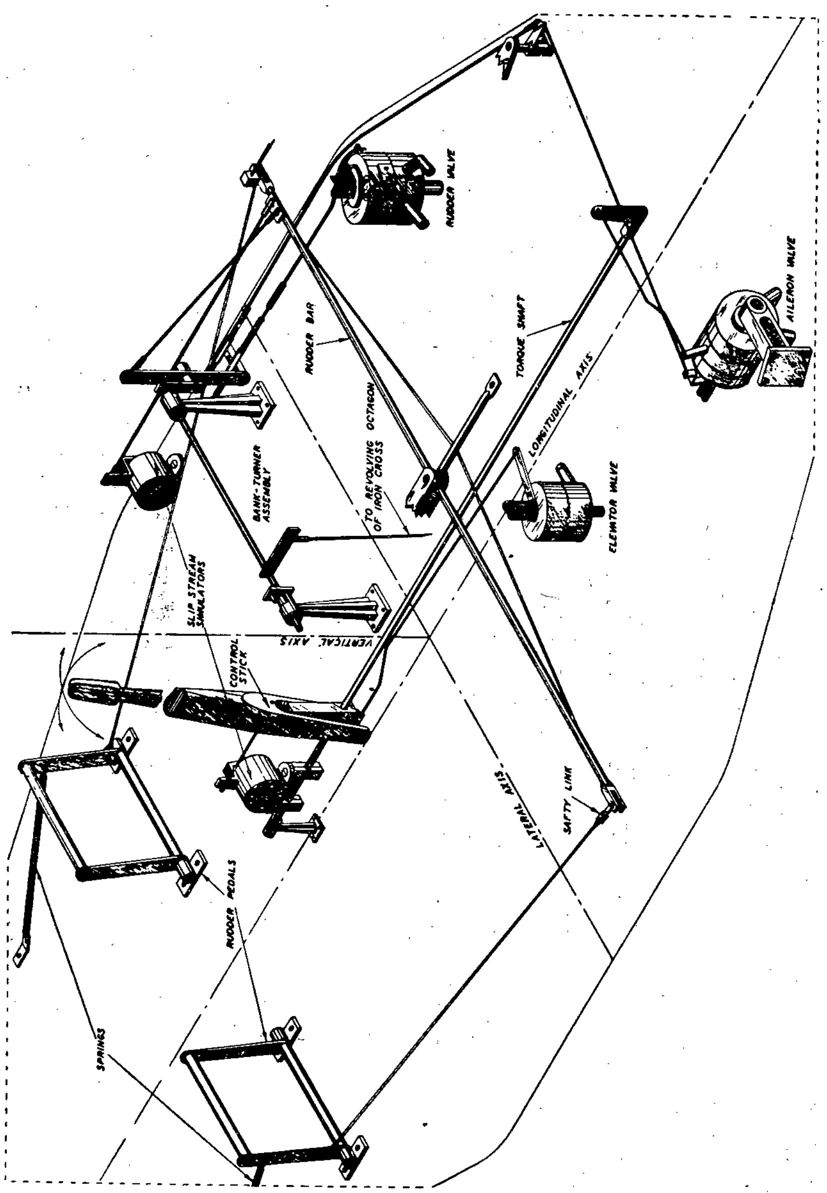


FIGURE 50.—Mechanical attitude control.

the stick. The base unit is constructed of two major parts. One part, the aileron control mechanism, swinging within the other part, which is the mechanism support and is mounted on the fuselage floor at the front end of the aileron torque shaft. The aileron torque shaft runs through the torque shaft rocker arm, through a bracket, and terminates at the connection to the aileron slip stream simulator. One end of the torque shaft rocker arm is connected by link rod to the control rocker arm, which is mounted just above the torque shaft and is a part of the base unit.

(8) When stick control is desired, the metal stick is screwed into the hole provided in the center of the control rocker arm. Lateral

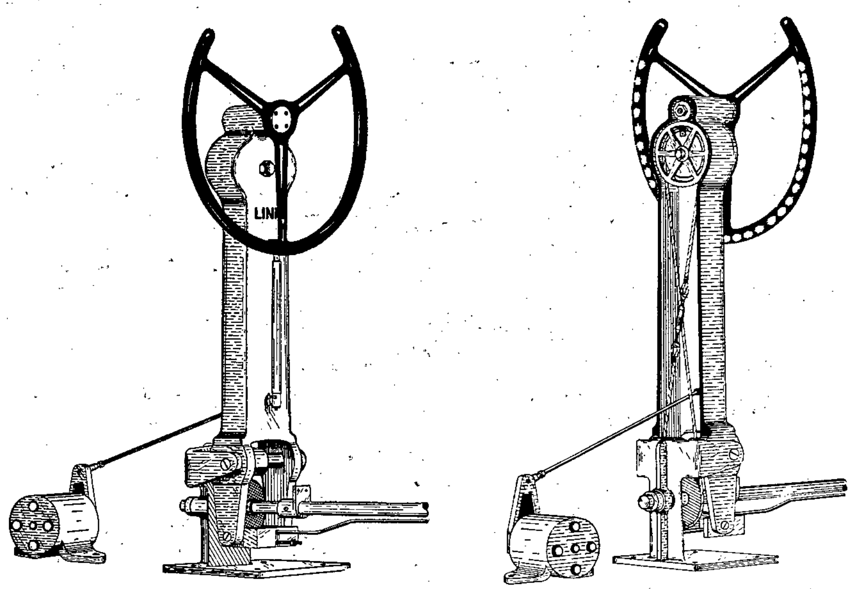


FIGURE 51.—Control column, C–2, C–4, C–5.

movement of the stick will cause a rocking movement of the control rocker arm, which will in turn, due to link rod connection, cause rocking movement of torque shaft rocker arm and rotary movement of the torque shaft, resulting in a bank in the direction of control movement. When wheel control is desired, it is necessary to remove the stick and replace it with the wheel control column, which is held in place by two cap screws. Attached to the shaft of the wheel is a small gear which meshes with a large quadrant-shaped gear. Attached to this gear is the link rod that connects to the control rocker arm.

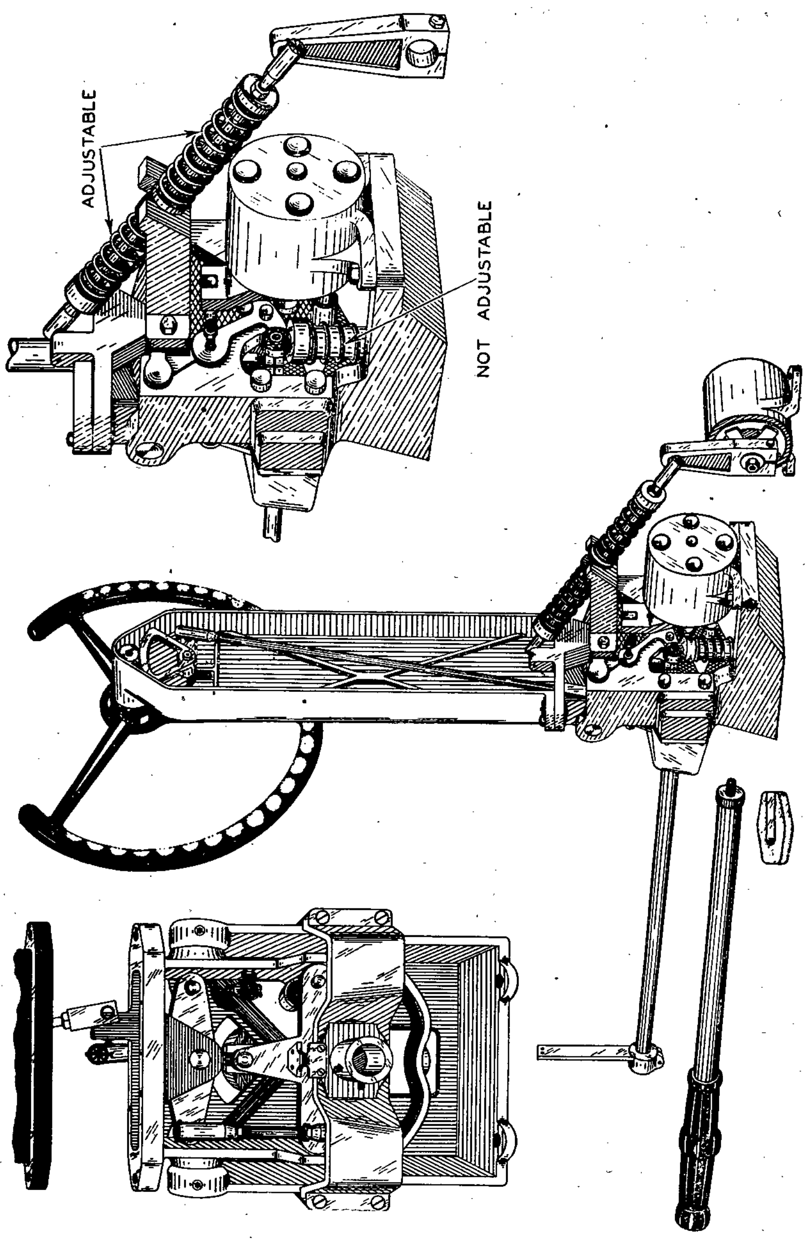


FIGURE 52.—Control column.

(9) By tracing the linkage through (fig. 52), beginning with wheel rotation, it can be seen that, facing the wheel, a rotary movement of the wheel to the right causes a rotary movement of the quadrant-shaped gear to the left, which pushes the link rod down causing the control rocker arm to move down at the control link rod connection and up at the other end, which in turn lifts one end of the torque shaft rocker arm, causing a rotary movement of the torque shaft, and finally a rotary movement of the top half of the aileron valve, resulting in a bank in the direction of control movement. The elevator control system consists of a simple direct-drive linkage system. Whether using wheel or stick control on any type trainer, the elevator control system is basically the same.

(10) Since all elevator control systems are basically the same, only the stick control of the C–2 trainer will be explained. The stick is mounted to the aileron torque shaft vertical arm at a single point and extends to a point below the torque shaft. This system of mounting the stick makes elevator control possible in that any fore or aft movement of the top part of the stick results in a reversed motion of the lower part of the stick, the pivot point being between the two ends. The pivot point is closer to the bottom of the stick, therefore a large movement of the top portion results in a relatively small movement of the bottom portion. This serves to reduce the motion so that there is a small amount of movement of the elevator valve; a small amount of valve movement being sufficient to correspond in action to a large amount of control movement. A link rod attached to the lower end of the stick extends toward the rear of the trainer and is attached to the top half of the elevator valve. Any fore and aft movement of the stick is transferred to and causes a rotary movement of the top half of the elevator valve, resulting in a change of attitude, either "nose-up" or "nose-down".

b. Instrument control system.—(1) Four instruments used in the trainer are mechanically controlled: the altimeter, vertical speed, air speed, and tachometer indicators. These four instruments are actually vacuum-operated but the application of vacuum in the instruments is mechanically controlled.

(2) To simulate actual aircraft conditions, it is necessary that the indications of these four instruments be affected by any change in throttle setting and/or any change in attitude, "nose-up" or "nose-down."

(3) Two separate assemblies are used to bring about these desired effects—the throttle assembly and the pitch-action assembly.

(*a*) The throttle assembly (unit A, fig. 53), consists of the following parts:

Name	*Drawing part No.*
Hand throttle	A-1
Throttle quadrant	A-2
Throttle link rod, adjustable	A-3
Throttle lever arm	A-4
Throttle lever arm pivot connection	A-5
Throttle link rod	A-6

(*b*) The pitch-action assembly (unit B, fig. 53), consists of the following parts:

Name	*Drawing part No.*
Pitch action bell crank	B-1
Pitch action torque shaft	B-2
Pitch action brackets	B-3
Pitch action vertical arm	B-4
Pitch action horizontal arm	B-5
Pitch action spring compensator link rod	B-6

(4) Both the pitch-action assembly and the throttle assembly terminate into a differential linkage (unit X, fig. 53), known as the walking beam. This walking beam is commonly referred to as "the pitch-action walking beam." The walking beam has five connections to it and is free to pivot at any one of these connections under certain conditions. The connections to the walking beam are as follows:

Name	*Drawing part No.*
Walking beam	X-1
Top connection, 1—pitch action bell crank	X-B-1
Second connection, 2—air speed link rod	X-E-1
Third connection, 3—tachometer link rod	X-D-1
Fourth connection, 4—throttle link rod	X-A-6
Fifth connection, 5—C/D valve link rod	X-C-11

(5) The altimeter and vertical speed indicators are affected through the climb and dive valve assembly (fig. 53), by the pitch-action assembly and/or the throttle assembly.

(6) The climb and dive valve assembly comprises two separate valves mounted on a single base and controlled mechanically as a

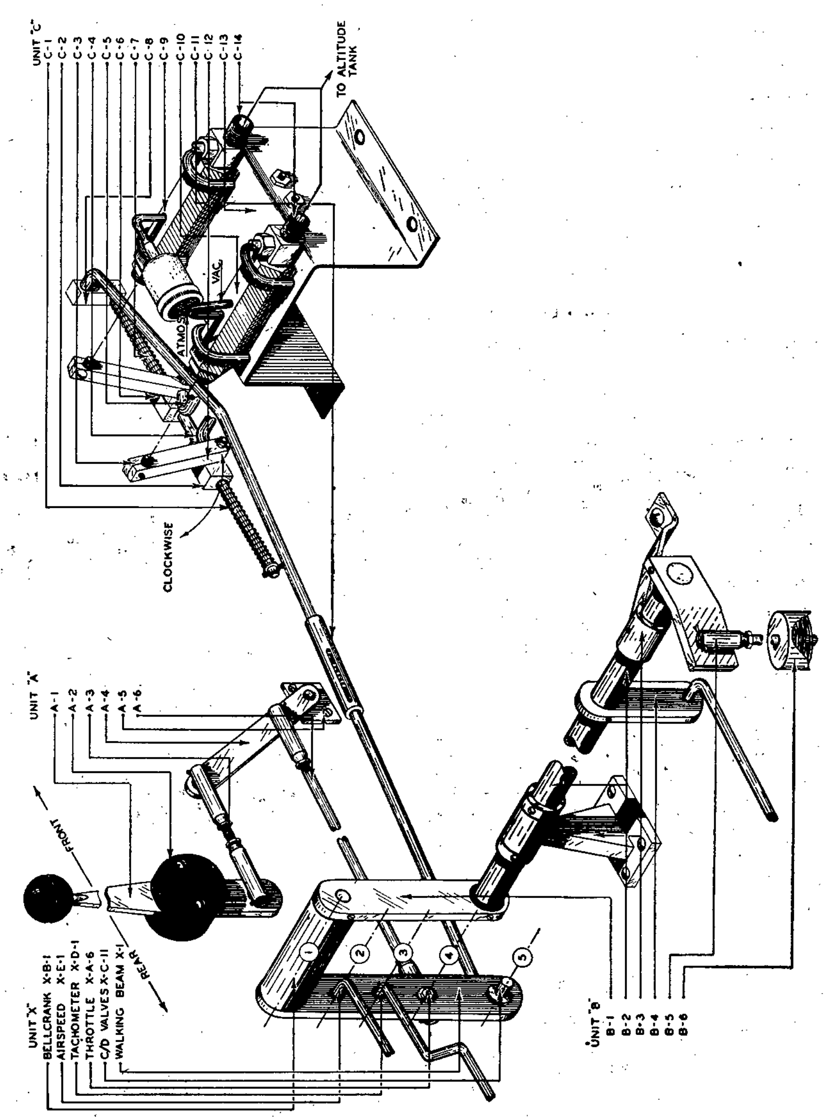


FIGURE 53.—Mechanical instrument control system.

unit. The climb and dive valve assembly (unit C, fig. 53) consists of the following parts:

Name	*Drawing part No.*
Valve actuating rod, spring compensator	C–1
Valve lever arm	C–3
Needle shaft	C–12
Climb valve	C–10
Dive valve	C–9
Limit valves	C–14
Climb-dive valve assembly base	C–13
Climb-dive valve spring compensator link rod	C–11

(7) The climb and dive valves control the pressure within the altitude tank. The climb valve is connected to vacuum, and the dive valve is open to atmosphere. Any time the climb valve is open, the altitude tank is being vented to vacuum, thereby reducing the pressure within the tank and creating a *simulated increase in altitude*. When the dive valve is open, the altitude tank is being vented to atmosphere, thereby increasing the pressure in the tank and creating a *simulated loss of altitude*.

(8) Due to the construction of the climb and dive valves, and the method of mounting and controlling them, only one of the two can be open at a time. On figure 53 it may be seen that if the valve actuating rod C–1, which is free to slide through brass blocks C–2 and C–6, were forced to move to the left, the spacer C–4 would strike climb valve brass block C–2 and move it to the left, thereby rotating the climb valve lever arm C–3 clockwise. The climb valve lever arm C–3 is attached to the climb valve needle shaft. Any rotary movement of climb valve lever arm C–3 is transferred to the needle shaft, which is threaded and screwed into the climb valve body C–10. The climb valve needle has a right-hand thread. Any clockwise movement of the needle shaft will screw the needle out away from its seat and open the valve venting the altitude tank to vacuum. When valve actuating rod C–1 was forced to move to the left, spring C–7 forced dive valve brass block C–6 against dive valve stop C–5, closing the dive valve C–9, which has left-hand threads on the needle. Any further movement of the valve actuating rod C–1 merely compresses spring C–7 against dive valve brass block C–6 and holds valve in closed position.

(9) When the foregoing explanation of the opening of the climb valve is understood, the same line of reasoning can be applied to the opening of the dive valve. However, it must be borne in mind that the valves are identical, except that the climb valve needle has a right-

hand thread and the dive valve needle has a left-hand thread. The valve actuating rod C–1 is forced either to the left or right by climb-dive valve link rod C–11 which is connected to the valve actuating rod C–1, brass block C–8 at one end, and to the pitch action walking beam at the other end. Hence, any movement of the walking beam at the climb-dive valve connections will result in either a climb or a dive.

(10) Referring to figure 53, the climb-dive valve assembly is actuated when the trainer is nosed up or down. It is connected by a pitch action spring compensator B–6 down through the fuselage floor to a member in the revolving octagon. Since the trainer floor tilts and the octagon does not, a movement of the pitch action shaft B–2 is caused which opens either the climb or dive valve, depending on whether the trainer is nosed up or down. Since the push-pull connection B–6 from the pitch action horizontal arm B–5 to the octagon is very nearly on the fore and aft center line of the trainer, banking has no appreciable effect on the climb-dive valves.

(11) It is necessary that the position or movement of the throttle also affects the altitude through the climb-dive valves. This is accomplished by means of a walking beam on the bell crank of the pitch action shaft. A differential is thus provided between throttle movement or position, and nose up or down movement of the trainer, and the resultant motion is transmitted to the climb-dive valves.

(12) For example, if the trainer is nosed up, the floor will be lowered at the point where the pitch action spring compensator B–6 extends down through to the octagon. This pushes the compensator B–6 upward through the floor and moves the arm B–5 upward. This rotates the pitch action shaft B–2, carrying the top end of the walking beam forward. Since the throttle was not touched, the walking beam X–1 is forced to pivot at point "4", where the throttle linkage connects. This swings the lower part of the walking beam in the other direction and pulls the climb valve open.

(13) Suppose, instead of the trainer being nosed up, the throttle has been opened. Pushing the throttle forward pushes the connecting linkage back at point "4". Since the pitch action shaft is stationary the walking beam is forced to pivot at point "1", again pulling the climb valve open. If both motions are applied, that is, the throttle opened and the trainer nosed up, the combined effect would open the climb valve farther than in either previous example. But if the throttle is opened and the trainer nosed *down*, the walking beam would pivot at point "5" while both "1" and "4" move in the same direction. This condition occurs when level flight (constant altitude) is maintained at full throttle. The amount that either climb or dive

valve is open at any time depends on the combination of throttle setting and the nose up or nose down attitude of the trainer.

(14) Indication of air speed and engine speed are also a result of a combination of the setting of the throttle, and nose-up or nose-down attitude of the trainer fuselage. The air speed system (Unit E, fig. 54) and the tachometer system (Unit D, fig. 54) consist of the following parts:

Air speed

Name	*Drawing part No.*
Link rod	E-1
Reversing arm	E-2
Link wire	E-3
Regulator spring	E-4
Regulator bellows	E-5

Tachometer

Name	*Drawing part No.*
Link rod	D-1
Reversing arm	D-2
Link wire	D-3
Regulator spring	D-4
Regulator bellows	D-5

(15) The air speed indicator and tachometer are vacuum-operated instruments and the amount of vacuum supplied to each is controlled by a regulator bellows E-5 and D-5. The action of the regulator bellows is in turn controlled by a mechanical linkage to the pitch-action walking beam in the same manner as the climb-dive valves. For example, when the trainer is nosed up the pitch action causes the walking beam to pivot at point "4" (fig. 54), the top end going forward and the bottom end back, pulling the climb valve open. At the same time, as the top end of the walking beam moves forward, it pulls the link rods E-1 and D-1 (fig. 54) forward. This pulls the top end of lever E-2 and the bottom end of lever D-2 forward and swings their opposite ends back, slacking off on springs D-4 and E-4. As the spring tension is decreased, the regulator bellows D-5 and E-5 will allow less vacuum to be applied to the indicators, and the readings of the air speed and tachometer will decrease. Due to the selection of the leverage ratios and regulating spring tension, the air speed is affected much more by nose-up or nose-down movement of the trainer than is the tachometer, while the throttle has an immediate, much greater effect on the tachometer than on the air speed.

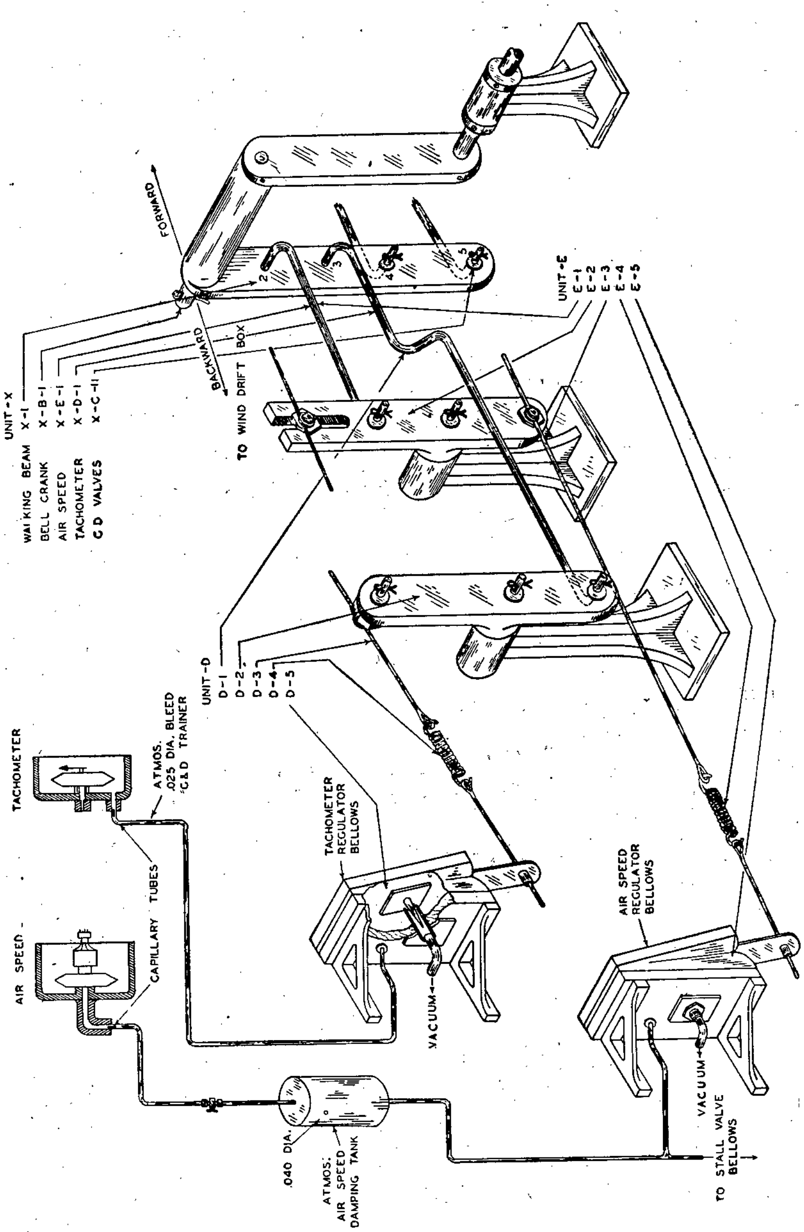


FIGURE 54.—Mechanical air speed and tachometer control system.

11. Electrical operation.—*a.* This manual does not include complete wiring diagrams for any trainer. Although all basic wiring of trainers is the same, different models incorporate new and different electrical hook-ups, junction boxes, control boxes, and terminals.

b. Each trainer delivered to the Army Air Forces is delivered with a Handbook of Instructions which contains the complete trainer wiring diagram; also trainers overhauled at depots are returned to the service with a set of wiring diagrams which may be peculiar to that trainer only.

c. Diagrams furnished by the manufacturer, by depots, or included in Technical Orders for the trainer or trainer model in question will be used when reference to diagrams is necessary.

d. The complete electrical system may be broken down into several systems that are, in general, common to all trainers. These systems will be covered as to their general make-up in section IV.

(1) *Radio and radio simulation.*—(*a*) Radio and radio simulating equipment for all trainers is designed so that the operator-instructor may, by means of various controls, simulate the actual sounds, identifications, peculiarities, and signals of the various radio aids to navigation. Since these radio aids have, from time to time, been improved and modified, and additional radio aids commissioned, older model trainers will include only apparatus for the simulation of those aids in use at the time of their manufacture, while the latest trainers incorporate means of simulating the latest developments of these aids.

(*b*) On all trainers, with the exception of the C–5 model the various signals are propagated and controlled at the operator's desk and transferred to the student's headphones in the trainer by metallic circuits. However, in the case of the C–5, actual radio waves are utilized in addition to metallic circuits. C–2 and C–4 trainers mount the radio simulating apparatus in the left-hand desk drawer, complete with the main chassis, keying device, radio compass control box, dry cells, and hand key.

(*c*) The C–2 trainer radio chassis (fig. 55) has mounted on its face the following controls: phone-code volume control, beam shift, circuit selector switch, course beam volume, course beam selector switch, marker beacon volume, marker beacon selector, cam motor switch, and line switch. In addition to the above controls there are five vacuum tubes, from left to right: a VT–37 marker beacon oscillator, VT–37 range beacon oscillator, VT–80 full wave rectifier, VT–37 "A" amplifier tube, and a VT–37 as the "N" amplifier tube. The phone-code volume control is the means of varying the amplification of the

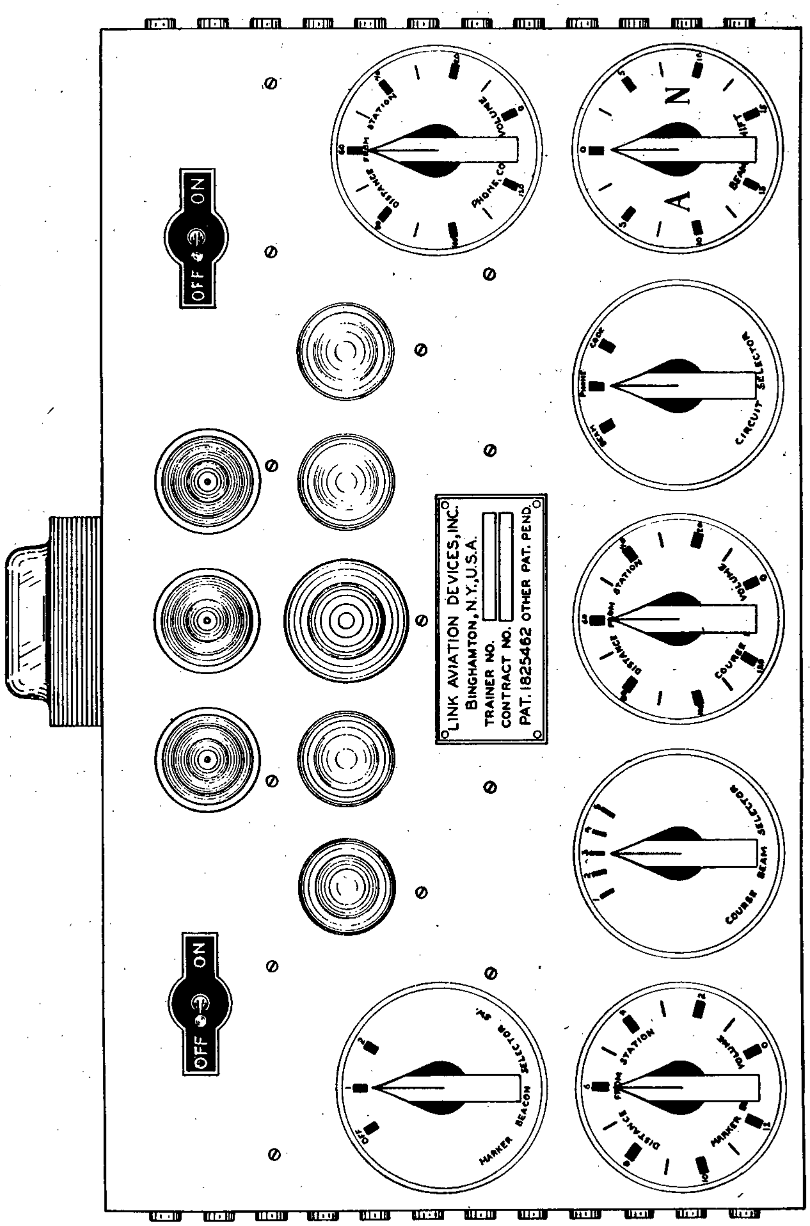


FIGURE 55.—Radio chassis, C–2.

voice and code signals originating at the desk or in the cockpit. The beam shift control varies the amplification or output of the two VT-37 "A" and "N" tubes, and in so doing creates the on-course double identification section and quadrant signals of a radio range. The three types of transmission, range, voice and code signals, are selected by the operator by means of the circuit selector switch. The course beam volume is a rheostat governing the signal intensity or volume of the radio range signals.

(*d*) Five different station identification signals consisting of two Morse code signals each, such as AZ and BV, are made available for selection by the operator through use of the course beam selector switch. More than one set of identifications is desirable, especially during advanced problems where several different radio ranges must be simulated in the course of one exercise or problem.

(*e*) This trainer simulates the aural marker beacon of the Lorenz system of instrument landing, but since this system is not used by the Army this signal must be modified to suit the Army system of instrument landings, by changing the keyed signals of the inner and outer markers to unkeyed signals, by adjustment to the keying mechanism.

(*f*) The outer station of the Army system employs an unkeyed, steady signal of 800 cycles, which is controlled by placing the marker beacon selector switch in the "outer" position. The inner station has a 400-cycle unkeyed note, and is simulated by placing the switch in the "inner" position. The volume control for these signals, to simulate the various distances from the transmitter of the airplane performing the problem, is located directly below the selector switch and is labeled "marker beacon volume."

(*g*) The small toggle, two-position switch, located on the left rear corner of the chassis is the cam motor switch and serves merely to turn on or shut off the 110-volt supply to the keying mechanism motor. The second toggle switch on the chassis is in the right rear corner and governs the application of the 110-volt supply to the complete chassis.

(*h*) The keying mechanism is a system of cam-operated spring relays that make and break the electrical circuits, of which they are a part, in such a manner as to interrupt that circuit while some additional contact keys the signal in such a manner as to produce Morse code identification signals, or the "A" and "N" quadrant signals. On the later trainers, incorporating keyed visual signals, the keying mechanism is provided with additional cams for this purpose. The cams are energized through a gear train driven by a small 110-

volt motor mounted on one end of the assembly, and controlled by the small on-off switch located on the radio chassis.

(*i*) The radio compass control box (fig. 56) mounted in the left desk drawer side mounts the following controls: On-off switch, reversing switch, volume control, and visual marker beacon switch.

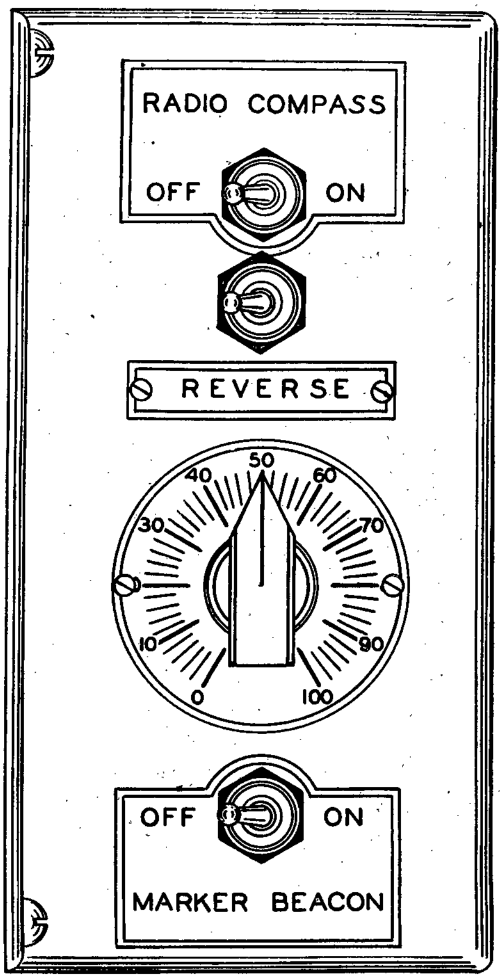


FIGURE 56.—Radio compass control box, C–2.

The first switch opens or closes the electrical circuit of the radio compass, and since this system employs the visual left-right indicator mounted on the fuselage instrument panel, it is necessary to incorporate a reversing switch that reverses the polarity of the electrical

circuit and so gives reverse indications on the meter. The volume control governs the amount of current applied to the indicator, and so governs the *amount* of deflection of the indicator needle. The visual indicator consisting of a neon lamp, mounted on the fuselage instrument panel, for the simulation of Z-type markers and fan markers, used in the Army system of instrument landings, is actuated by the marker beacon switch.

(*j*) In the rear compartment of the drawer that contains the radio simulating equipment are located the banks of 1½-volt batteries that serve the radio compass and the phone circuit. Two banks of series wired 1½-volt batteries, three to each bank for the radio compass, and one bank of two, series wired, batteries for the phone circuit.

(*k*) Located in the cockpit of the C-2 model, on the instrument panel, is the small subpanel upon which are mounted the phone and microphone jacks into which the plugs of the headset and microphone used by the student are inserted. On this same panel is the call signal switch and the volume control.

(*l*) When the signal selector switch on the radio chassis is in the "Range" position, only range signals may be used; however, since it is necessary for the student in the trainer to call the operator at the desk or "ground", during the course of some problem, the call switch has been provided, which when placed in the "On" position superimposes a 60-cycle hum upon the range signals, and so informs the operator that the student wishes to talk, whereon he simply places the selector switch in the voice position and informs the student to "Go ahead."

(*m*) The volume control controls only the range signals being received, being entirely out of the voice circuit. This condition is necessary so that the operator may have the only control over the volume of the voice circuit, and may keep it at a comfortable readable audio level.

(*n*) The key in the cockpit is provided for the student's use in case code transmission is desired during the course of a problem.

(*o*) Figures 57, 58, and 59 show the lay-out of the radio simulating equipment common to the C-4, C-5, and C-3 trainers.

(*p*) The radio system for the C-5 trainer was developed from and as a result of the survey of trainer operators in the field, and includes the following features: rotatable loop direction finding; a standard aircraft receiver in the student's cockpit; two-way communication (control tower, etc.); Z marker and fan markers, aural and visual; simultaneous voice range with filter; instrument landing systems. In addition to the radio receiver with rotatable loop, the C-5 radio sys-

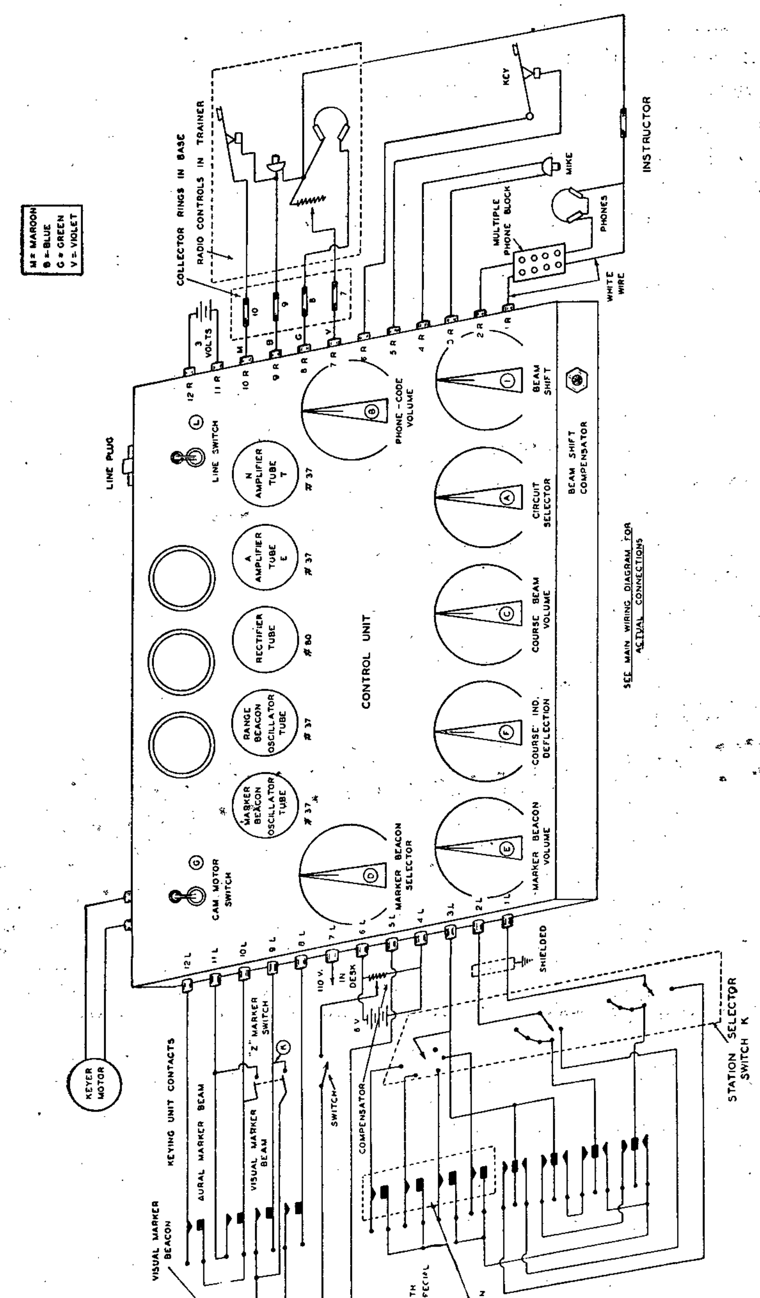


FIGURE 57.—Radio simulating equipment, C-4.

tem includes an omnidirectional antenna, two transmitters, a control chassis, and an associated power supply with the necessary interconnecting equipment. The transmitting antennas are mounted in a box suspended directly over the trainer hood. Thus, while the transmission is actually by means of radio, the distance transmitted is only a few inches; consequently, the power is low to minimize possible interference with other receivers. The two transmitters on the control

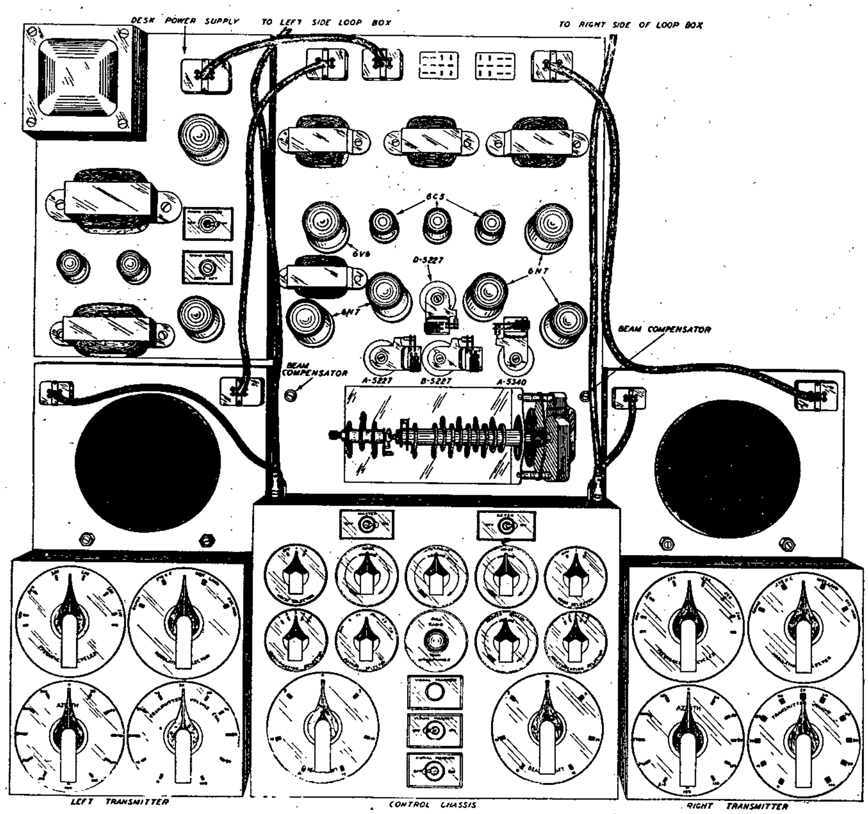


FIGURE 58.—Radio equipment, desk C-5.

chassis are located conveniently in the middle drawer of the instructor's desk. Controls on each of the transmitters provide for a choice of transmitting frequency between 200 kc and 400 kc. Distance from station is controllable by means of a transmitter volume control. An azimuth control is provided on each transmitter for producing a directional field on which the student may take bearings. Each transmitter has a fourth control which permits a choice of modulation including

radio range, a position for control tower (278), modulation for instrument landing markers, and for external modulation such as phonograph records or actual broadcast stations picked up on another receiver.

(*q*) The control chassis located between the two transmitters contains two A–N mixer controls for radio range signals (one for each transmitter). Oscillators for the various modulation frequencies are included in this control chassis, also their selection and volume controls. This control chassis also includes provision for direct inter-

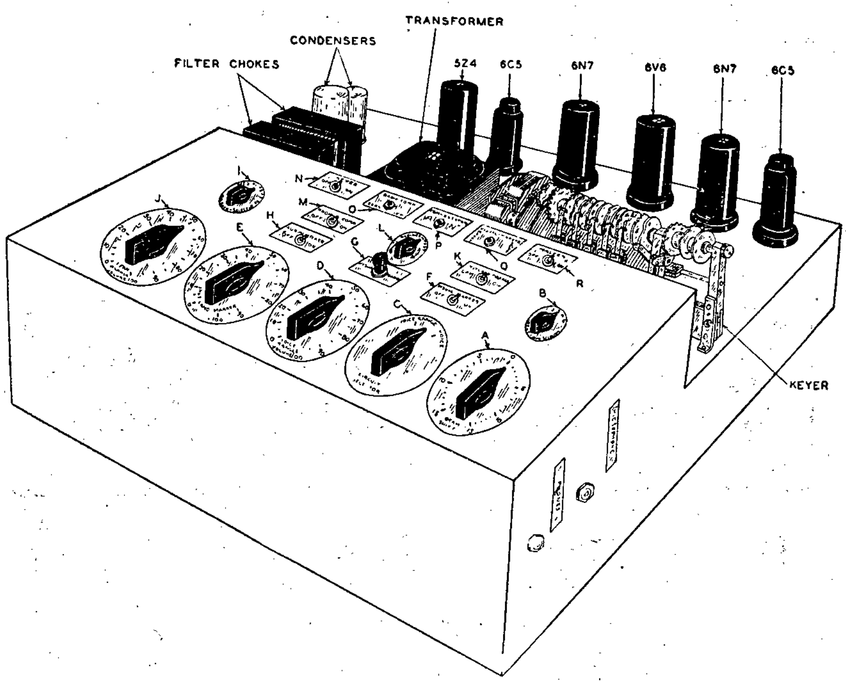


FIGURE 59.—Radio simulating equipment, C–3.

phone with the student regardless of his handling of the receiver in the cockpit. Separate controls are provided for the introduction of external modulation (outside radio stations, etc.) to each of the two transmitters. Incorporated in this control chassis is an automatic keying device which keys the A's, N's, and other code signals. Located in the cockpit, in addition to the radio receiver, is its power supply and a separate control box with the necessary interconnecting cables.

(*r*) Types C–4 and C–3 are designed to simulate the radio aids that were in general use at the time of their conception, the C–3 being

the latest type, incorporates means of simulating all aids in use at the time of this writing.

(2) *Telegon system.*—(*a*) The Telegon instrument system provides a means whereby the instructor at his normal place at the desk may have a constant positive check upon the indications of the trainer's air speed and vertical speed indicators and the altimeter. On trainers previous to the C–4 model it is necessary for the instructor either to estimate these indications from the trainer's attitude or leave his position at the desk and look into the cockpit through the peephole on the right side of the fuselage.

(*b*) This system incorporates a transmitting unit, consisting of the actual instrument and a Telegon transmitter for each of the instruments located in the rear of the fuselage. (See figs. 60 and 61.) These transmitters control three metallic circuits, the readings indicated by two repeater instruments, one located on the cockpit instrument panel and the other on a panel at the instructor's desk. The repeater instruments are nothing more than calibrated instrument faces with an indicating hand which is moved over this face by movements of its Telegon motor receiver which is controlled by the master Telegon or transmitter at the actual instrument.

(*c*) The power supply, 80- to 90-volt, 800-cycle, is provided by the Telegon oscillator located in the trainer base.

(3) *Accessories.*—(*a*) Direct lighting is provided in the cockpit of the trainer by two small adjustable "moonbeams", one mounted on the door and the other on the top longeron on the right side. These lights use 12-volt, 6-cp, double-contact bulbs. Current is obtained from the 110-volt, 12-volt transformer mounted on the back of the instrument panel on C–2 and C–4 types and on the rear of the fuselage on the power supply unit underneath the rear transmitter panel on the C–5. Should it be necessary to trace the wires, it should be remembered that current for the left-hand light is conducted into the door through the door hinges.

(*b*) The recorder light uses two 25-volt, 2-ampere, single-contact bulbs mounted in an adjustable bell on the inking wheel spindle shaft. These bulbs are connected in series to obtain power from the 32-volt terminals, marked "A" and "G," on the recorder Teletorque or Autosyn motor (fig. 62). Since these bulbs are connected in series, one bulb will not light if the other is burned out. Any break in the circuit will shut off both lights.

(*c*) Instruments on all trainers have luminous dials, and additional lighting on C–5 models is provided for by rim lighting of all the instruments. A very small light is built into each instrument, as an

integral part, with current in this circuit controlled by a separate rheostat. C-3 models provide fluorescent and ultra-violet light, by means of flexible mounted lamp assemblies. A power supply for each lamp is obtained from the two transformers located in the bottom of the cockpit control box. Bulbs for these lamps are the 4-watt size. Amount of light is governed by the shutter control located on the top of each lamp. The second control of this unit is accomplished by rotating the case, providing daylight or ultra-violet light. Ultra-violet lighting is accomplished by a violet screen built into the case.

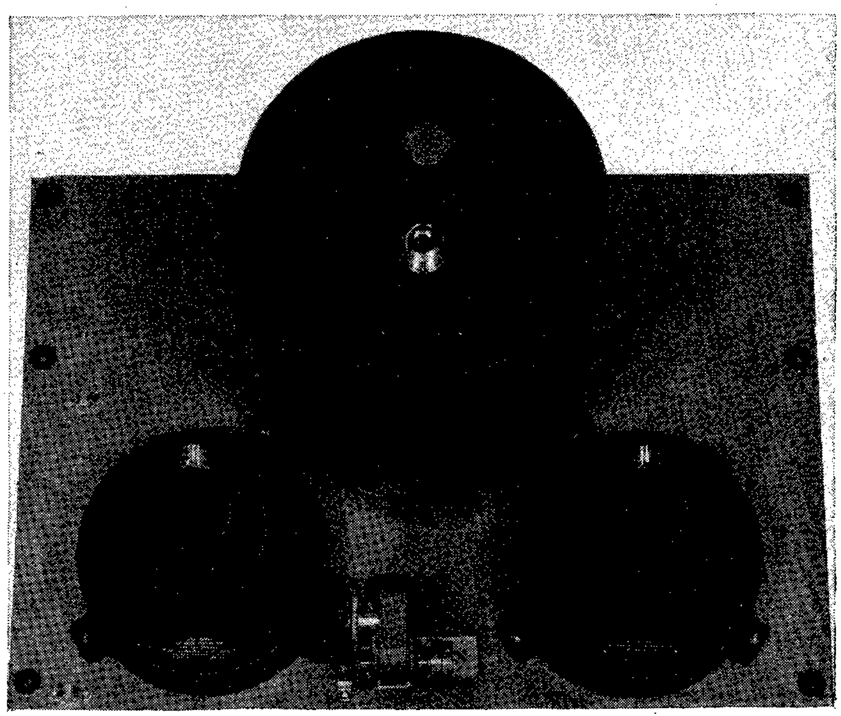


FIGURE 60.—Telegon transmitting panel.

(*d*) The desk light provided as standard equipment on C-5 and C-3 trainers is part of the recorder cable and light support mounted on the rear of the metal desk and extending over the desk proper. This light is of the conventional 110-volt type, obtaining its current from the 110-volt supply in the desk junction box.

(*e*) A 110-volt electric fan is provided in the nose of the trainer to ventilate the cockpit. This fan is a standard unit requiring only occasional oiling and care ordinarily given such a unit.

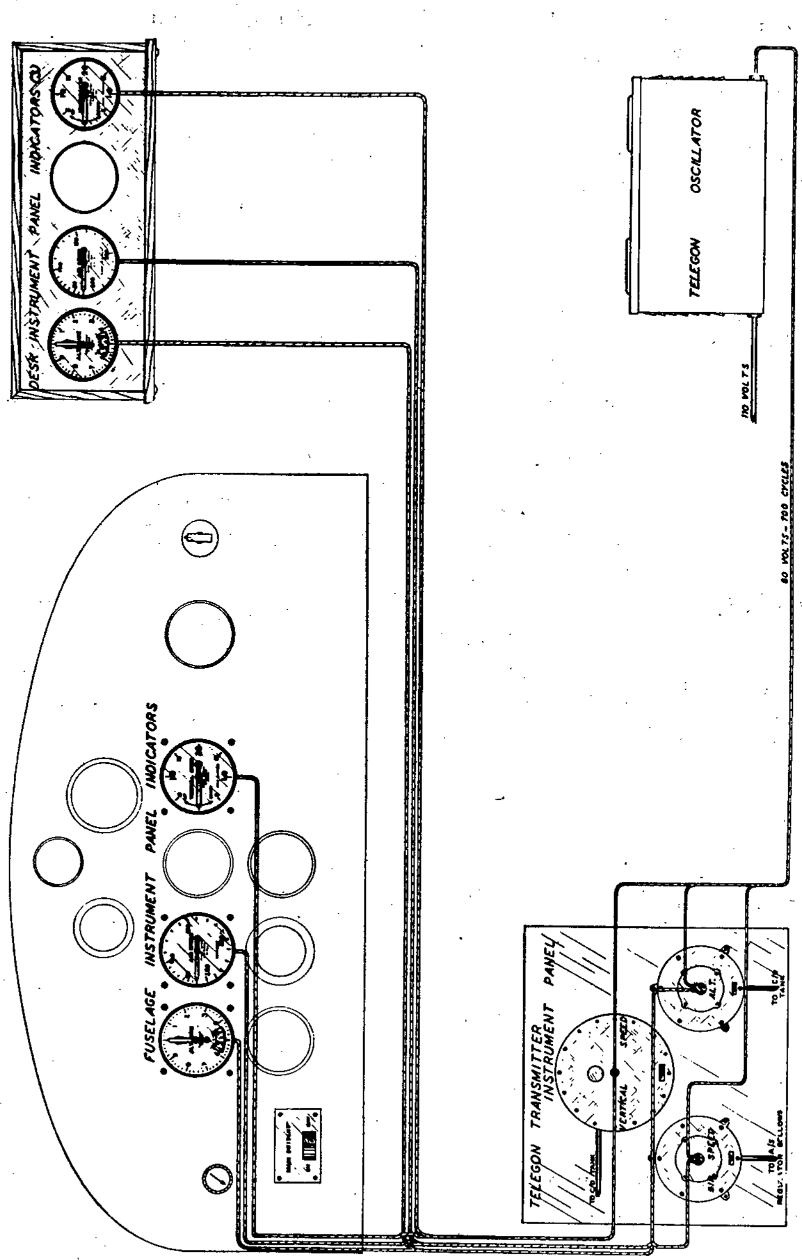


FIGURE 61.—Telegon system—schematic.

(*f*) The rough air drive motor located under the fuselage seat performs a dual purpose on C-2, C-4, and C-5 models, being the means of actuating the rough air cam assembly and also having a fan mounted on its forward end that helps in the fuselage ventilation by evacuating part of the hot air generated by the turbine that rises along the main spindle. This unit is supplied from the 110-volt source in the fuselage junction box or on the fuselage terminal block.

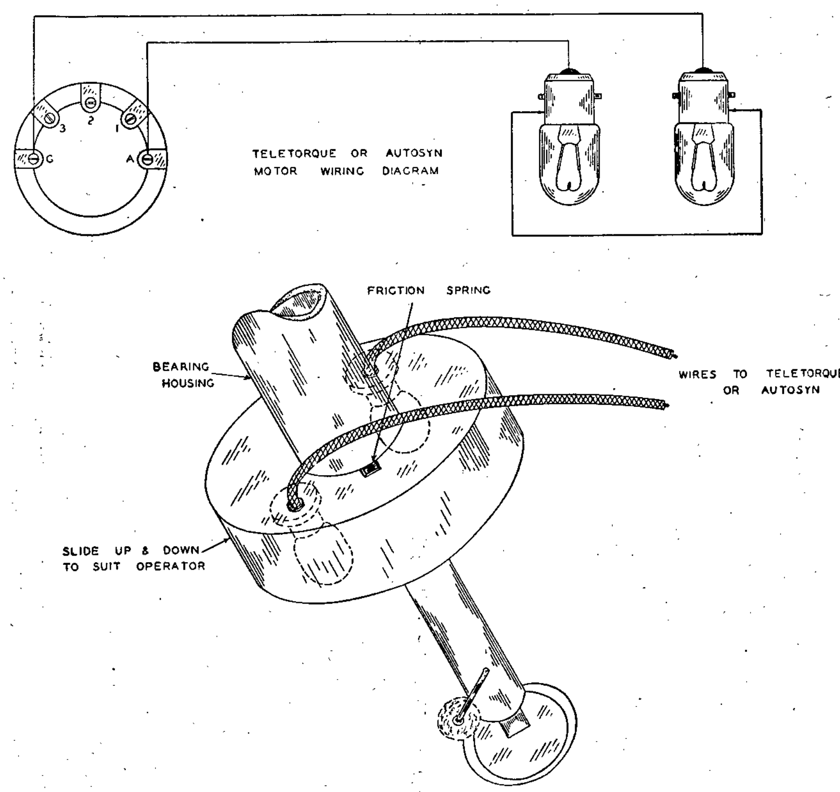


FIGURE 62.—Recorder lights.

A different type motor, one similar to the keyer motor, is provided to drive the rough air assembly on C-3 models. This new type assembly does not include a fan.

(*g*) Since the trainer has very little natural vibration, which is necessary to keep the instruments "alive," 110-volt vibrator motors are provided. These motors drive an eccentric wheel to give vibration to the instrument panels and are located as follows: One on

the back of the main instrument panel, one at the transmitter panel, and one in the desk instrument box. Trainers not equipped with the Telegon remote instrument panel mount only one vibrator, it being on the instrument panel back.

(*h*) The C-3 model incorporates simulated de-icer equipment consisting of an electrical circuit governed by the on-off switch on the cockpit instrument panel. A small neon lamp is mounted adjacent to the icing valve in the rear of the fuselage which glows when the switch is placed in the "On" position which informs the instructor that the student has realized the "icing" condition and has turned on his Pitot tube heater to rectify the condition; whereon the instructor opens the icing valve permitting normal operation of the air speed indicator.

(4) *Automatic recorder.*—(*a*) The flight log travels over the chart or map on three wheels. Two of the wheels are drivers and the third is an "inking wheel" which leaves an inked track on the chart. Two synchronous telechron motors are geared to the driving wheels and provide forward travel of the recorder. Directional control is obtained with an Autosyn, or Teletorque motor on late models, located in the center of the flight log. Each of the three wheels is attached to a vertical shaft. At the top of each shaft is a large gear. All three of these large gears mesh with the small pinion gear on the Autosyn motor. Thus when the Autosyn motor is caused to rotate, the three large gears and their shafts also rotate and steer all three wheels. It will be seen from this that the three wheels should always be headed in the same direction. A similar Autosyn motor is located in the trainer base and geared to the vertical main shaft of the trainer. It is a characteristic of the Autosyn motor that when the one in the base is rotated (by the trainer turning), the Autosyn in the recorder duplicates the turn. This steers the recorder and causes it to faithfully trace on the chart the turns made by the student.

(*b*) When the trainer main switch is turned on, the Autosyn motors "come alive" and line up with each other. Since the one in the base is geared to the main spindle and so cannot move unless the trainer is turned, the one in the flight log rotates and lines itself up with the one in the base. Between the Autosyn pinion gear and the large gears in the recorder, there is a gear ratio of 12 to 1. Consequently, when the Autosyns "come alive" and line up with each other, the recorder will jump to the nearest of any one of 12 headings. If the flight log is properly synchronized, it will be necessary only at the start of each problem to spin the large gears around by hand

until the inking wheel is headed the same direction on the map as the trainer fuselage is headed by the compass. The trainer heading is shown by the cards on the octagon.

(5) *Compass deflectors.*—(*a*) In order to simulate the gyrations of the magnetic compass common in an airplane compass due to northerly turning error, it is necessary to introduce some means of causing the same thing to happen to the compass, which is a standard aircraft instrument, in the trainer. To simulate this northerly turning error, which takes place whenever a change of heading is made, whether it is a controlled change or an inadvertent change due to rough air conditions, a device known as the compass deflector is incorporated in the trainer.

(*b*) This unit, on all but early C–2 models, consists of a small electromagnet mounted directly below the compass on the back of the instrument panel. Current is supplied by the 12-volt transformer and a rectifier circuit, controlled by the set of adjustable contacts mounted on the bottom half of the rudder valve and a third contact on the top half.

(*c*) On early models of this electric compass deflector the complete unit, rectifier, adjustable resistor, terminal, and magnet are mounted on the back of the instrument panel but on later models only the electromagnet is on the panel, the other component parts of the circuit being mounted in the fuselage control box.

(*d*) The earliest model compass deflector, with which a few units may still be equipped, consisted of a vacuum-operated mechanism that moved by mechanical means a small permanent magnet under the compass in such a manner as to create this error. Due to various reasons, but mainly because of the lack of flexibility for fine adjustments, this unit has been discarded by the manufacturer in favor of the electrical system.

(6) *Fuel gage.*—(*a*) The fuel gage (fig. 63) is a clockwork with a single pointer and a dial graduated in gallons. After being wound up to its full capacity of 50 gallons, it requires approximately 1 hour to run down. When the pointer has run down to the zero mark, a switch is automatically opened. This switch is wired in series with the trainer main switch (ignition switch) so that when the gage reads empty and this switch is opened, the trainer is automatically turned off. A toggle switch is provided, located just above the ignition switch, which is wired so as to bridge the switch in the fuel gage. When this switch is closed, the switch in the fuel gage has no effect on the operation of the trainer.

(*b*) A special key is provided with which the fuel gage is wound up like a clock. This key is ordinarily retained by the instructor. The mechanism consists of a mainspring, a short train of gears, an escapement similar to that in a clock, plus the switch. The unit can be wound to any value desired by the instructor according to the particular problem about to be run.

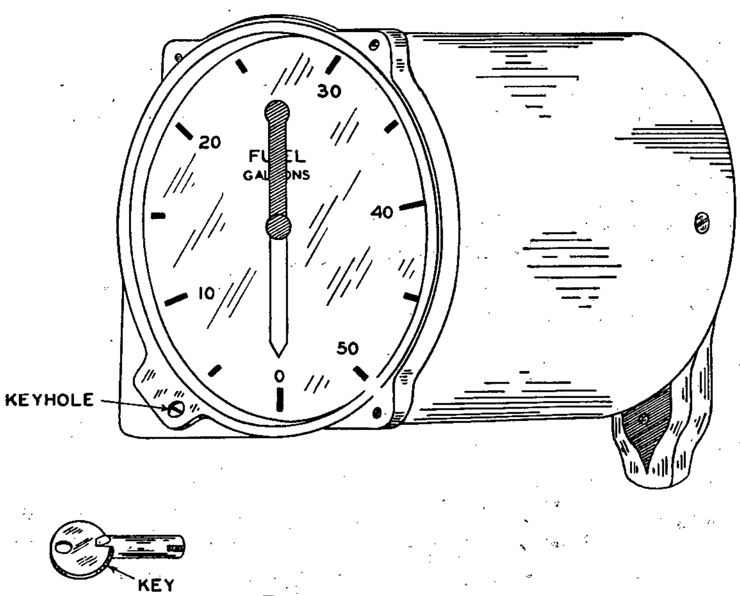


FIGURE 63.—Fuel gage.

SECTION IV

DETAILS OF PARTS AND SUBASSEMBLIES; REGULATING AND ADJUSTING

12. General.—This section is devoted to the individual units and subassemblies. Each unit or system is completely covered by drawings and explanations as to their entire physical make-up, regulation, and adjustment.

13. Vacuum turbine.—*a. Handling.*—This machine has been carefully balanced and tested at the factory to insure proper operation. Service and maintenance of this machine must be strictly adhered to for maximum operating efficiency.

NOTE.—It is recommended that the machine be relocated away from the trainer, outside of the trainer room. However, in so locating the turbine, do not place it more than 20 feet away from the trainer. It must be carefully protected from dampness and dirt.

b. Turbo-compressor (turbine).—Operating on a line voltage of 115 volts, the turbine is designed to produce not less than 4⅜ inches of mercury. Under normal operating conditions with a $\frac{5}{16}$-inch air bleed in the intake, the turbine will draw 12 cubic feet of air per minute with a constant voltage of 115 volts. When testing the turbine for maximum output, insure the proper voltage of at least 110 volts, preferably 115 volts, if available.

c. Motor.—The motor furnished with this machine is a $\frac{3}{4}$ hp universal type designed to operate at 7,500 revolutions per minute. Being a universal type motor, a commutator and brushes are essential for its operation. If a light pin spark is noted during operation at the point where the brush contacts the commutator, do not be concerned as this is a normal characteristic for this type of motor. This pin spark may, however, cause radio interference to nearby radio receivers. Technical Order 08-5-19 explains in detail how a noise filter may be fabricated and installed to eliminate such interference. It is possible to change the speed of the motor slightly by shifting the end bell on the motor to increase the turbine efficiency. ***Caution:*** When shifting the end bell, do not shift it more than a slight amount and only when the voltage is of the proper amount (110-115 volts). To increase the speed of the motor, turn the end bell slightly in a clockwise direction by reference to the white marks painted on the end bell and motor housing. This is accomplished by loosening the four bolts that hold the end bell in place and shifting the end bell slightly to the right. When the voltage is low, no attempt should be made to pick up vacuum by shifting the end bell as this will result in too high a vacuum when the voltage returns to its normal operating level.

d. Commutator.—The commutator of this motor should be kept clean and free from dirt at all times. To facilitate cleaning the commutator, a bakelite cap is located in the top of the end bell and may be removed easily by removing the screws which hold this cap in place. By inserting a clean cloth dampened with carbon tetrachloride through the hole, dirt and grease may be removed while the commutator is running. If the commutator is extremely dirty, it may be cleaned with very fine (No. 00) sandpaper very carefully used. This will help if the commutator is somewhat rough. *Never use emery cloth.* If the commutator is extremely rough or has ridges, it will be necessary to remove the motor assembly from the turbine and turn down the commutator. After turning the commutator, it must be undercut at least $\frac{1}{32}$ of an inch. More than a $\frac{1}{16}$-inch cut to clean up the commutator will cause the characteristics of the motor to change.

e. Brushes.—The motor brushes must slide freely in the brush holders and not be allowed to wear to a point where only $\frac{3}{16}$ inch of brush is left. If they wear to this point, the spring fails to keep them in perfect contact with the commutator. The life of the brushes is approximately 1,500 running hours. However, this life may be shortened considerably unless they are properly serviced. If

the brushes wear to the minimum before the approximate life, they must be replaced immediately. When replacing the brushes, they must be of the same type and grade as previously installed, and the commutator must be dressed with a careful application of fine sandpaper. However, when ordering replacement brushes, it is necessary to include the information concerning the turbine, lot number and motor number, as well, to be sure of obtaining the proper set of brushes. Later model turbines and motors employ the use of a one-piece brush rather than two-piece brushes as formerly used in previous models of this machine. The later type brush is available but requires the new type brush holder as well as the brush, also a minor alteration of the end bell to fit the new brush holder into the end bell.

f. Magnetic switch.—Late type trainers are provided with a magnetic switch arrangement for the turbine for the purpose of keeping the relative high current, present in the lines when the turbine is first energized, from the lines running through the spindle and into the fuselage. On figure 64, it may be seen that when the trainers main switch, labeled "Ignition switch" on late models, is closed the electromagnet (A) is energized and closes the 110-volt circuit serving the turbine by pulling the contact assembly to the closed position. When the main switch is opened the electromagnet loses its magnetic properties and so permits the spring (C) to open the turbine circuit.

g. Lubrication.—The only lubrication required is the two bearings located in the motor. The lubrication points are in the form of grease cups at each end of the motor. Bearings are grease lubricated and are packed with sufficient grease to last about 100 running hours when they leave the factory. Ordinary greases are not suitable for the bearings. Only a high-grade grease having the following general characteristics should be used for the ball bearing lubrication: preferably about 275° F. melting point, freedom from separation of oil and soap under operating or storage conditions, freedom from acids, alkalis or abrasive matter. The Army Air Forces specification for the lubricant meeting the above requisites is as follows: grease, lubricating, high melting point, grade 210, spec. 3560. Bearings should be relubricated about every 100 running hours. When refilling the bearings be careful not to overlubricate them, as overlubrication results in excess grease being thrown onto the commutator and brushes, causing heavy sparking and rapid wear of the brushes and commutator, thereby reducing the efficiency of the turbine motor. To prevent excess lubrication and to insure proper lubrication, the following procedure is recommended: The turbine should be operating for at least 30 minutes before the greasing operation is started, to allow

the motor and the bearings to attain their normal operating temperature. Before the greasing operation is started, remove both drain plugs located on each end of the motor under the bearing retainers. Wipe the area around the grease cup free from any contamination and remove the grease cup. Fill the grease cups with the specified grease and inject the new grease. If there is no indication of old grease appearing at the drain plug opening, a wire may be inserted through the opening into the bearing retainer to insure that the drain opening is not clogged with old hard grease. Repeat the procedure of applying the new grease until the new grease appears at the drain plug opening. *Stop greasing at this time.* Allow the unit to run for another 10 or 15 minutes with the drain plugs open to expell any excess grease. *This is important.* When the activity of the excess grease ceases coming out of the drain plugs, replace them both. During the greasing operation, great care should be taken to keep the lubricant free from contamination.

h. Ball bearings.—The ball bearings in this machine are of special design particularly adapted to the work which they have to perform. One bearing is designed to carry both the radial and thrust loads developed by the impellers. Do not be concerned if this bearing runs warm, as this is consistent with normal operation. Both the bearing and the grease with which it is lubricated will stand a temperature of 200° F. without danger. Unless the bearing temperature exceeds this amount, there is no cause for concern. Since the ball bearings in this equipment are of special design, it is essential that exactly the same bearings are used in replacement, if this becomes necessary. Both bearings are interchangeable and replacement bearings can be obtained through Army Air Forces supply.

i. Dismantling turbine.—Considerable time is spent balancing and testing this machine in order to insure efficient operation. If it is necessary to dismantle the turbine, the parts *must* be placed in exactly the *same relative position*, to prevent unbalancing the turbine. To insure that the reassembling is accomplished properly, it is suggested that a mark be placed on each impeller, deflector head, etc., as the machine is dismantled so there will be no mistake in reassembling. Whenever the turbine must be dismantled, it is necessary that this procedure be followed (fig. 65): Begin at the intake and remove in turn the end head (A), impeller (B), spacer (C), packing (D), deflector head (E), impeller (F), etc., until all impellers and head spacers and deflector heads are removed. Division head (G) should not be removed. It is necessary that all parts are kept in their respective

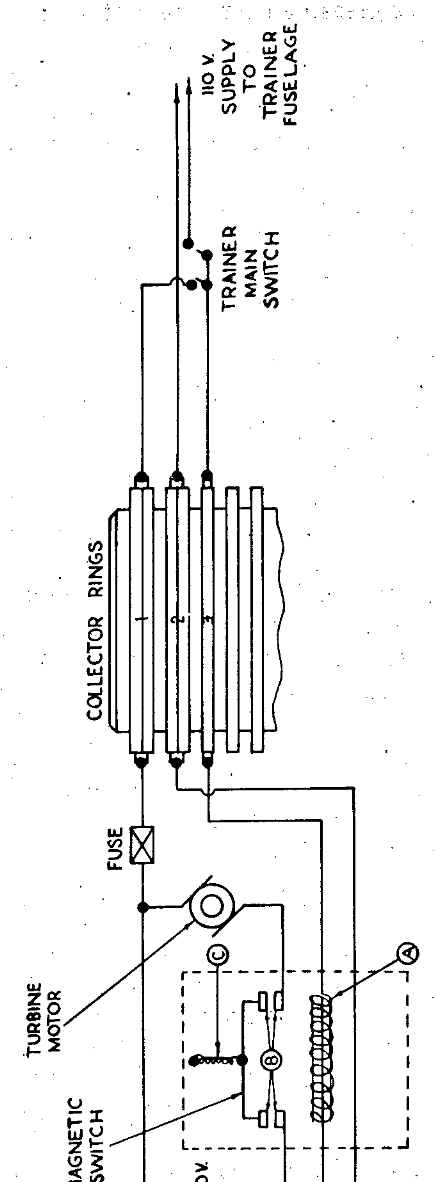


FIGURE 64.—Magnetic switch, turbine—schematic.

order when removing them and placed in a position that will facilitate reassembly.

j. Reassembly of turbine.—(1) After the motor is cleaned and overhauled, it may be reassembled and secured in position. See that packing (D) is in place and tight around the shaft, and if it is disarranged in removing the motor or otherwise, a new packing should be installed before going farther, start the motor and make sure that the shaft runs absolutely true. ***Caution:*** Do not let the motor run without a load on it. This can be accomplished by placing one impeller on the shaft and clamping it in place. One impeller will produce sufficient load to prevent the motor from racing which may otherwise cause damage. After testing, remove the impeller and start the operation of reassembling the turbine impellers and deflector heads.

(2) Place the first impeller (H) on the end of the shaft but do not tighten it. Next place deflector head (I) in the casing and push the deflector head and impeller together until the deflector head is against the head spacer (J). Insure that the deflector head, spacer, and impeller are in place. Remove the deflector head (I) from the casing and with the aid of a scribe, scratch the shaft at the impeller hub. Push the impeller back against the division head (G) and return it half way to the scratch mark on the shaft. Tighten the impeller hub bolts a little at a time being careful not to change the position of the impeller on the shaft or to fracture the clamp. Replace deflector head (I). Follow this by placing head spacer (K) in position and next, impeller (L) on the shaft as previous installation of the impeller (H). Next place deflector head (M) in casing and push impeller and spacer against head spacer (K). Remove deflector head (M) from the casing and mark on the shaft of the impeller hub. Push the impeller as far back as possible and return it half way to the scratch mark. Tighten the impeller hub bolts and replace the deflector head. With the aid of a screw driver or similar tool, calk the packing (D) firmly into the groove. If available, a new packing should be used. When calking, be sure it is done evenly, otherwise the deflector head will be off center and cause rubbing of the impellers.

(3) Continue this procedure until all impellers are assembled in the casing. Install a new gasket between casing and end head. Tightening of bolts and drawing the end head onto the casing must be done evenly to prevent misalinement of head spacer deflector head. When the turbine assembly is completed, it may be connected to 110–115-volt supply and tested. With a $5/16$ bleed, the turbine should

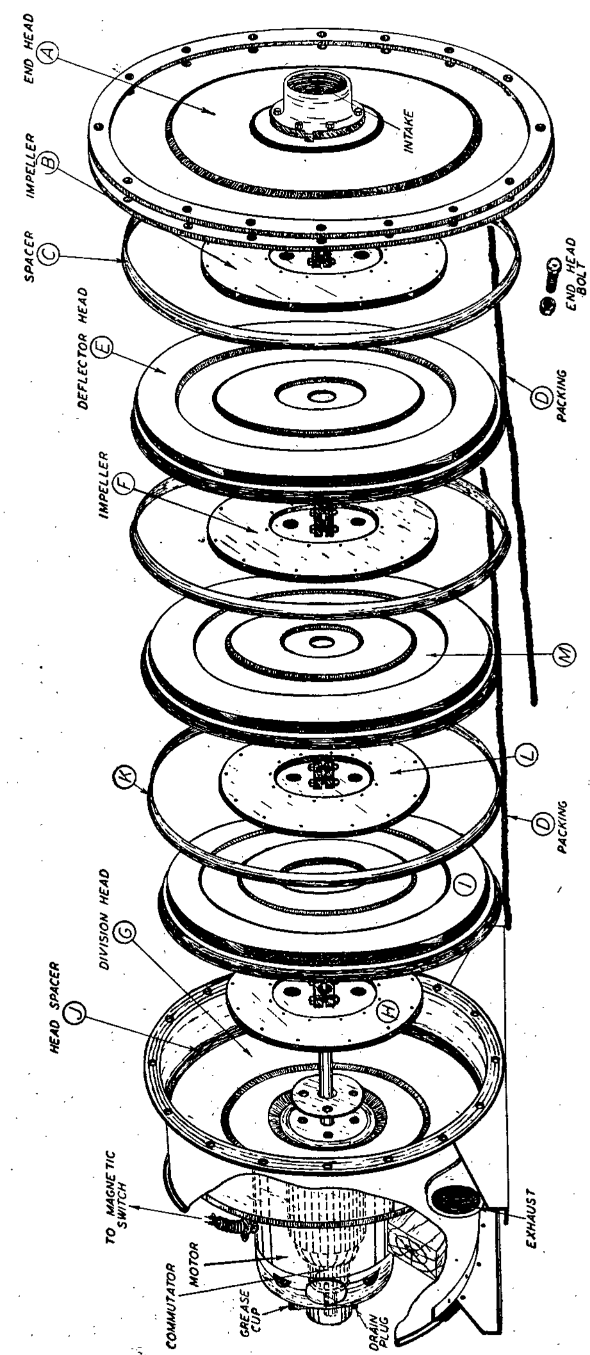


FIGURE 65.—Vacuum turbine.

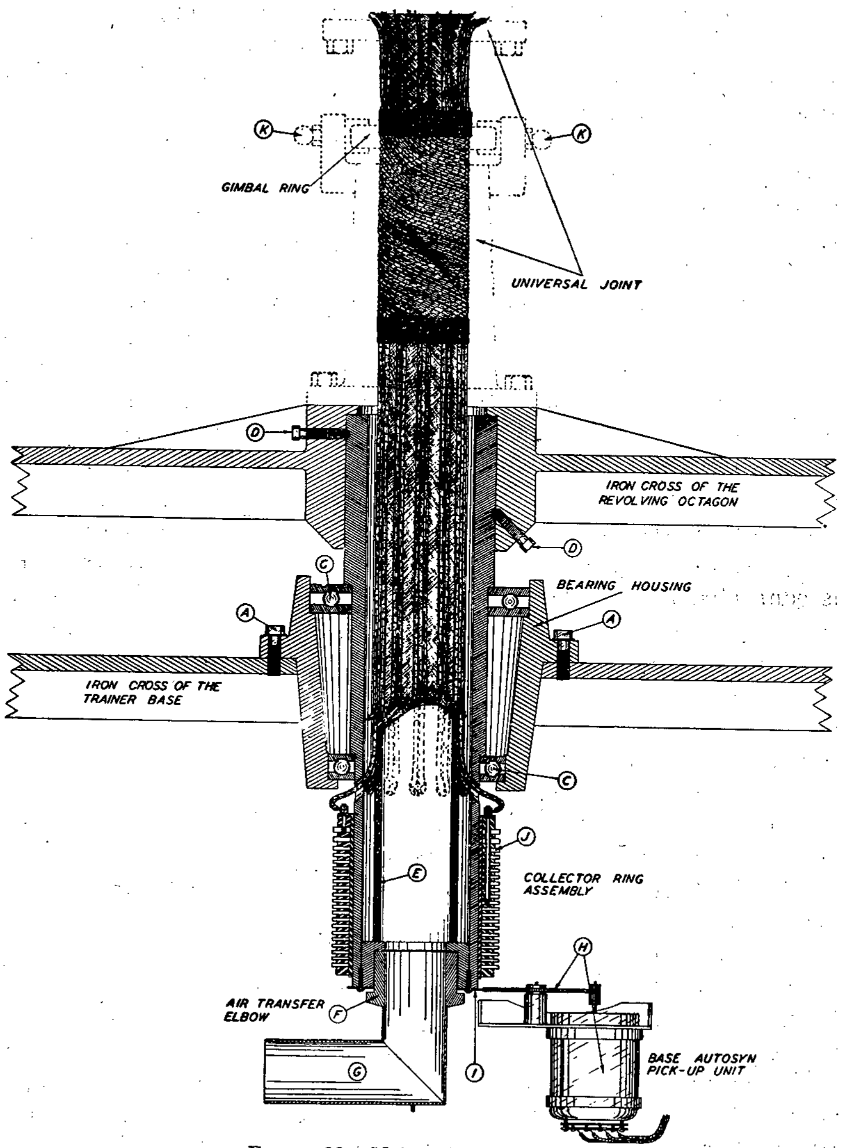


FIGURE 66.—Main spindle, cutaway.

draw 12 cubic feet per minute or a gage indication of not less than $4\frac{3}{8}$ inches of mercury. Never attempt to run the turbine with a damaged, repaired, or dirty impeller as their unbalanced condition will cause excessive vibration and may wreck the machine.

14. Spindle (fig. 66).—*a.* Attached by four stud bolts (A) to the iron cross of the base is the main bearing housing (B) of the spindle, which houses, as its name implies, the two large ball thrust bearings (C), which in turn support the fuselage and octagon and permits them to rotate through 360°. The spindle itself is of steel construction and extends through the bearing housing from inside the base into the octagon, which rests on its top and is secured by two setscrews (D).

b. Attached to the spindle at the base end is the collector ring assembly (J), which turns with the spindle and serves as the means of completing the various electrical circuits running from the fuselage to the base junction box. This unit is served by the brush assembly, which is mounted by a bracket to the bearing housing.

c. To provide a means of furnishing the various units in the fuselage with the necessary vacuum supply, a black drill-covered rubber hose (E) is used inside the spindle. This hose extends through the complete assembly into the fuselage. At the bottom of this hose is connected a steel sleeve (F) and cast iron elbow (G), connected to the turbine, which is fitted closely and oil sealed, forming an airtight rotating joint.

d. The Autosyn pick-up assembly (H) is mounted on the same bracket as the brush assembly and is energized by a gear train, which in turn is actuated by the brass gear (I) mounted on the air-transfer sleeve.

e. The necessary wiring which runs through this spindle, runs from the collector ring through holes, drilled in the steel spindle, into the fuselage between the inside wall of the spindle and the air-transfer hose. Late model trainers use 21 collector rings, and have 23 conductors (two spare) running by way of the spindle into the fuselage. These wires run straight until they reach a point where they run through the center of the main universal joint, at which point they are secured by tape and then wrapped around the hose in a spiral wrap for approximately $4\frac{1}{2}$ inches, at which point they are taped again and then run straight into the fuselage. This spiral wrap is provided to eliminate the tension and twisting action that would normally be placed on these wires in a "straight wired" spindle, and so increase the life of this wiring.

f. Routine maintenance of this unit is very simple, but must be performed diligently. The collector ring and brush assembly must be checked weekly; the brushes and contact arms cleaned with carbon tetrachloride, or in cases of extreme roughness with very fine crocus cloth; the wiring must be inspected at the terminals and other visible points; the elbow sleeve cleaned and relubricated with heavy oil or light grease, and the Autosyn pick-up gear inspected and cleaned if necessary.

g. Due to the lack of excessive friction and the resulting heat, it is unnecessary to relubricate the main bearings, which are packed in heavy grease, except at overhaul periods, unless the trainer is operated over a long period of time in extremely warm weather, or in a room that is extremely dirty. If the latter is true, it is advisable to clean and relubricate these bearings at the 500-hour inspection period.

15. Universal joint.—*a*. Supporting the trainer fuselage, mounted on the center of the iron cross of the octagon, is the main universal joint which, due to its construction, permits banking and pitching action to take place in excess of maneuver normally indicated by the instruments in an airplane. This unit, secured to the iron cross by four stud bolts is of cast iron construction and comprises a tapered pedestal with forked top to which is mounted (by two bearings) the gimbal ring. (See fig. 67.) Attached to the other two bearing points are the forked arms of the top platform of this assembly which is fastened to the fuselage floor by four stud bolts extending through the floor and into the platform. The main air transfer column and the base to fuselage wiring runs through the center of this assembly into the fuselage.

b. Bearing plugs are provided at each connection to the gimbal ring equipped with zerk lubrication fittings. However, lubrication of this unit can be overdone quite easily, resulting in the lubricant, medium grease, leaking through on the wiring and transfer hose causing considerable deterioration of the insulation and the rubber hose. In view of these facts great care should be taken in lubrication of this unit. As a general rule this unit will not require lubrication more than once every 500 hours, at which time it is advisable to dismantle the unit and clean and relubricate the bearings.

c. Due to the fact that the parts of this assembly are of cast iron, the gimbal ring should be checked closely in its inside surfaces for rough or abrasive surfaces which would tend to wear the electrical conductors and so cause shorts and opens. Should this condition be

found to exist, the inner surface of the gimbal ring should be dressed and polished before the spindle is rewired.

16. Control valves.—*a.* Three of these valves all similar in design are used: rudder, aileron, and elevator. Details of construction

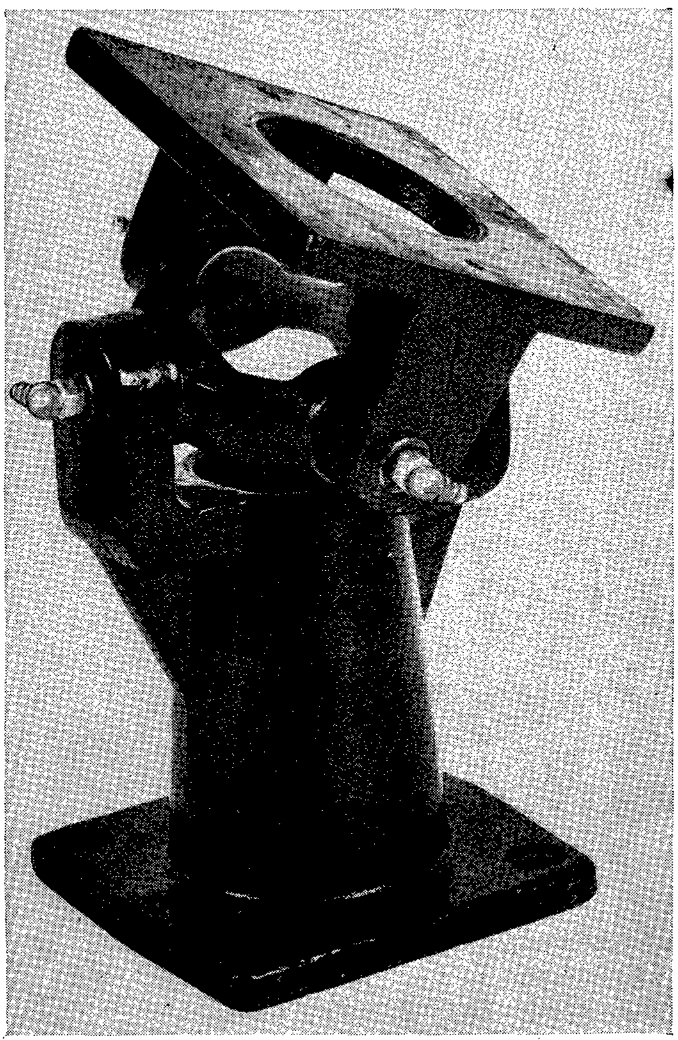
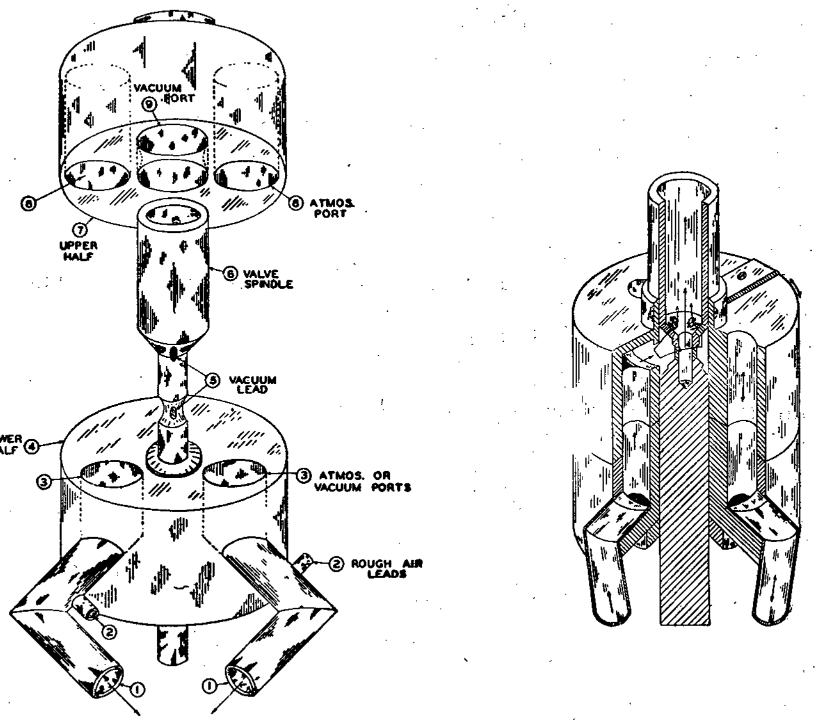


FIGURE 67.—Universal.

(elevator valve) are shown in figure 68. The suction supply is attached to tube (A) which is connected through the holes at (B) to port (C) in the top half of the valve. In the neutral position this port is between and slightly overlapping the two ports (P) in the

lower half. In this position, due to the overlap, a small amount of vacuum is applied to both bellows attached to this valve, and both these bellows will be pulling downward equally. Movement of the wheel (or stick) rotates the top half of the valve, and moves port (C) over one of the ports in the lower half. When one bellows is drawn closed, it is necessary to provide a way for air to get into the other. When the supply port (C) is moved over the bottom port leading to one bellows, one of the exhaust ports (D) is moved over



① ②

FIGURE 68.—Elevator valve.

the port leading to the other bellows, thus opening it to atmosphere. Outlets (E) are part of the rough air system.

b. With the trainer running and maintaining a level flight position (locks disengaged), the wheel (or stick) and rudder pedals should be in a neutral position. If the controls are not neutral, proceed as follows:

(1) *Rudder valve*.—Set the rudder pedals even with each other and turn on the trainer. The bottom half of each main valve is fitted into a metal socket and held in place by a setscrew. The rudder valve is

located under the right rear corner of the seat and the socket extends down through the fuselage floor. This socket and the setscrew are reached from outside the trainer, under the cloth skirt. Be sure the spin-trip is in normal flight position, then loosen the setscrew and rotate the bottom half of the rudder valve one way or the other until the trainer has no tendency to turn. Tighten the setscrew and recheck that the rudder pedals are even with each other.

(2) *Aileron valve.*—(*a*) *Wheel control.*—Turn on the trainer and remove the side locking strap and set the control wheel where the trainer will fly level. The wheel control cable passes over a pulley at the bottom of the column. Without disturbing the attitude of the trainer, loosen the setscrew in the pulley. Hold the long shaft, on which this pulley is mounted, from turning and put the control wheel in a neutral position. Retighten the setscrew. At the rear end of this long shaft, an arm is located which connects to the aileron valve. The setscrew in this arm should be checked for tightness; also the setscrew in the valve socket.

(*b*) *Stick control.*—This is similar to the above except that the adjustment is made with the lever arm at the rear of the long control torque shaft, or with the fixed half of the valve.

(*c*) *Interchangeable stick-wheel control.*—(*a*) Turn on the trainer and center the wheel with neutral spring action and loosen lever arm on the end of the long torque shaft.

NOTE.—Rudder valve and center leaf of aileron valve must be centered first.

Move the lever arm right and left without turning long shaft, until the trainer remains level and floats in the side strap. Recheck stick or wheel for center and secure lever arm to shaft. Recheck trainer for level and "floating" in side strap.

(3) *Elevator valve.*—(*a*) *General.*—This valve will seldom require adjustment, due to its direct linkage to the wheel column or stick. Should it be required, simply place the control column or stick in a vertical position and adjust the lower half of the valve so that the trainer will remain level with the rear lock off.

(*b*) *Stick-wheel control unit.*—This assembly is similar in adjustment to the ordinary stick control type, except due to the variable spring loading unit, it is necessary to insure that the stick or wheel column is in a vertical position before attempting to adjust the elevator valve to neutral. Should it be necessary to change the position of the stick or wheel forward or back to obtain the vertical position, it is accomplished by loosening the bottom spring lock nut and increasing bottom front spring tension to move the stick or column back, or decreasing spring tension to move it forward.

Tighten lock nut and proceed to adjust lower half of the elevator valve so the trainer will remain level and "float" in the rear strap. Excess play in this linkage is removed by adjusting ball nuts on the spring assembly.

(4) *Adjustment of aileron valve to neutral, automatic bank type.*—(*a*) First make sure that the spin-trip assembly is in its normal operating position and that rudder pedals are in line with each other straight across the fuselage. Leave the trainer turned off. Note the two large elbows which extend out of the bottom of the aileron valve. These elbows should be on a line level with the fuselage floor. Lock the base (fixed portion) of the valve in this position by means of the lock screw in the bracket.

(*b*) The next step is to position the center leaf. The desired position of this leaf is with its stop midway between the two dowel pins located in the fixed part (base) of the valve. (See fig. 69.) To get the center leaf in this position, adjustment must be made on the link rod (D) attached to the center leaf on one end and to the bell crank (E) on the other end. If sufficient adjustment cannot be obtained on this rod, an additional amount may be obtained from the ball joint on the rod (F) leading from the bell crank to the rudder valve walking beam. After adjusting the fixed portion (A) of this valve and its middle leaf (C) to the desired position, proceed with the final adjustment as in (*c*) below.

(*c*) Turn on the trainer, leaving the side and rear locks engaged. Make sure that the spin-trip mechanism has returned to its normal position and that rudder pedals are in a straight line across the fuselage. Then loosen the lock screw in the lever arm (G) located on the rear end of the torque shaft, which connects by means of a short link rod (H) to the front half (B) of the aileron valve. Put the stick or wheel in its neutral position. Then with the trainer still running, adjust the position of the aileron valve lever arm (G) and with it the movable part of the valve, to a position where the trainer is "floating" in the side lock. When this condition is obtained, tighten the lock screw in the aileron valve lever arm. Recheck the control column and rudder pedals to make sure they are still in neutral.

(5) *Nose heaviness during turn.*—(*a*) Most airplanes have a tendency to nose down during a turn. This tendency is reproduced mechanically in the trainer by means of special ports in the rudder valve. Referring to figure 70, note that this valve is similar to the valve shown in figure 68. Figure 68① is the bottom of the valve, which is mounted in a socket fastened to the floor of the fuselage. The two large ports labeled "To turning motor" are the same as

shown in figure 69. Figure 70 ② is the upper half of the rudder valve, which is connected to the rudder pedals. Note that the four large ports are exactly the same as those shown in figure 68. To obtain

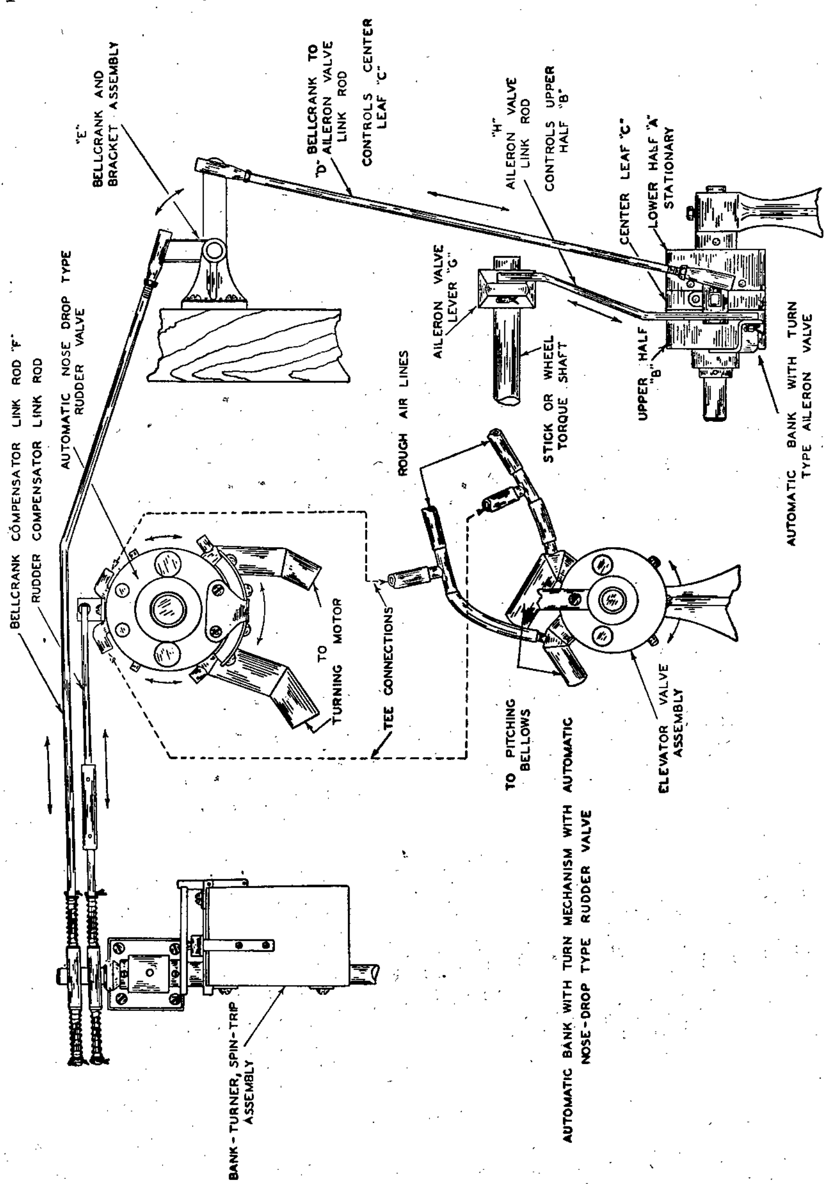


FIGURE 69.—Control valve—schematic.

the nose-down action, the additional ports shown in figure 70 are added. In figure 70① note that one of the ports and its attached elbow leads to the front (dive) bellows, and the other port and elbow lead to

the rear (climb) bellows. It will be seen from this that permitting vacuum to enter the port leading to the front bellows will pull the nose of the trainer down. In order to permit this, it is necessary also to permit atmosphere to enter the rear bellows.

(*b*) Referring to figure 70② note that there are two ports marked "Vacuum." When this upper half of the valve is in place on the lower half (fig. 70 ①), it will be seen that these two vacuum ports straddle the port (F) which leads to the front bellows. Consequently, appli-

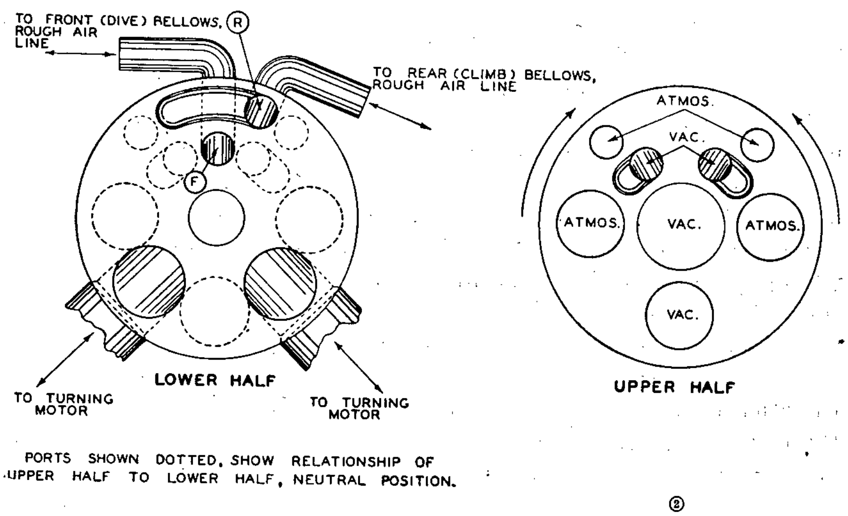


FIGURE 70.—Rudder valve.

cation of the rudder in either direction will cause one of these vacuum ports to slide over the port leading to the front bellows. The remaining two small ports labeled "Atmosphere" straddle the slot (R) which is cut in the lower half of the valve and which connects to the rear bellows. Note the two atmospheric ports are so placed that whenever rudder is applied and the valve moved in either direction, one or the other of these two atmospheric ports is slid over the slot leading to the rear bellows. There is no provision for adjusting the amount of nose heaviness during turn. The proper proportion is arrived at in the design of the valve and the location of the holes.

(6) *Automatic bank.*—(*a*) Nearly all airplanes will automatically bank to some extent whenever rudder is applied, without the aid of the ailerons. This is obtained in the trainer by means of interconnecting the aileron valve with the rudder action.

(*b*) The aileron valve is practically the same as the main valve shown in figure 68. A complete understanding of this valve should

be obtained before attempting to understand the automatic bank feature. It will be noted in the study of figure 71, that control of vacuum is obtained by moving or rotating the upper half of the valve. A little thought will show that by holding the upper half of this valve stationary and rotating the lower half, the same result would be accomplished. Since it is not possible to rotate the lower half, due to hose connections, etc., a third part was added (see fig. 71). This third part "C" consist of a center leaf between the upper and lower halves. The ports (holes) in this middle portion of the valve coincide exactly with those in the bottom or fixed portion of the valve "A". Consequently, when this middle portion "C" is rotated, the effect is exactly the same as would be obtained by rotating the lower half of the valve as shown in figure 71. Note that the ports in the middle leaf "C" are countersunk on the side which faces the bottom or fixed portion of the valve. This is done so that movement of the middle leaf will not hamper the flow of vacuum through the bottom or fixed portion of the valve. With this middle portion of the valve stationary, movement of the upper part of the valve "B" (which is connected to the aileron control), results in the same action as would have been obtained without the middle leaf as connected by linkage to the control column so that it is actuated by sideward motion of the stick or wheel. The middle leaf "C" is connected by linkage to the rudder pedals. Consequently, when the ailerons are applied, the upper half of the valve is rotated, causing the trainer to bank. If the ailerons are left in neutral and rudder applied, the center leaf rotates, thus also causing the trainer to bank.

(7) *Lubrication.*—(*a*) All main valves should be removed, cleaned thoroughly, and lubricated, with medium heavy oil, at least once every 50 hours of operation. Where trainers are operated in extremely dry climates, it is recommended that these valves be checked every day and if necessary relubricated.

(*b*) Lack of sufficient or proper lubricant will not necessarily damage these units, but will result in jerky movement of the moving parts of the valves and rough trainer movements. For example, if the rudder valve becomes dry or very dirty the two halves will adhere to each other so much that when rudder is applied the first part of the motion will be absorbed in the springs of the spring compensator link rods until they are fully compressed, whereon the top half may break loose and be rotated suddenly against its stops, thereby applying suddenly the full vacuum supply to the turning motor. Keep all parts clean and well lubricated, being care-

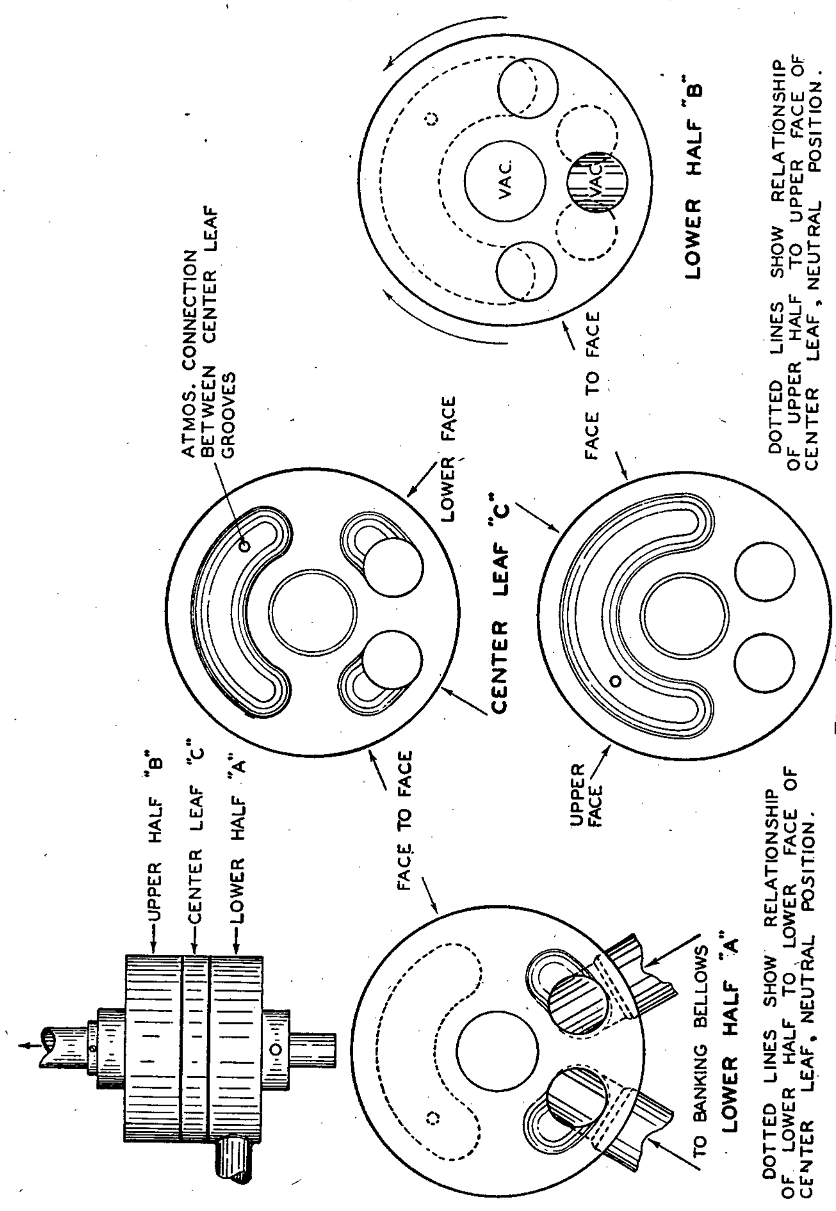


FIGURE 71.—Aileron valve.

ful to wipe off excessive oil to preclude any possibility of its leaking on to the rubberized fabrics or hoses, causing deterioration.

17. Slip-stream simulator.—*a.* These units are designed to stiffen, or load, the elevator, aileron, and rudder control.

b. The body of the unit contains vanes on the large shaft which operate in fluid-filled compartments. The fluid flows from one side of each vane to the other side through a controllable valve which can be adjusted to furnish the desired resistance, or stiffness, of elevator or rudder control. Protruding from the unit is a large

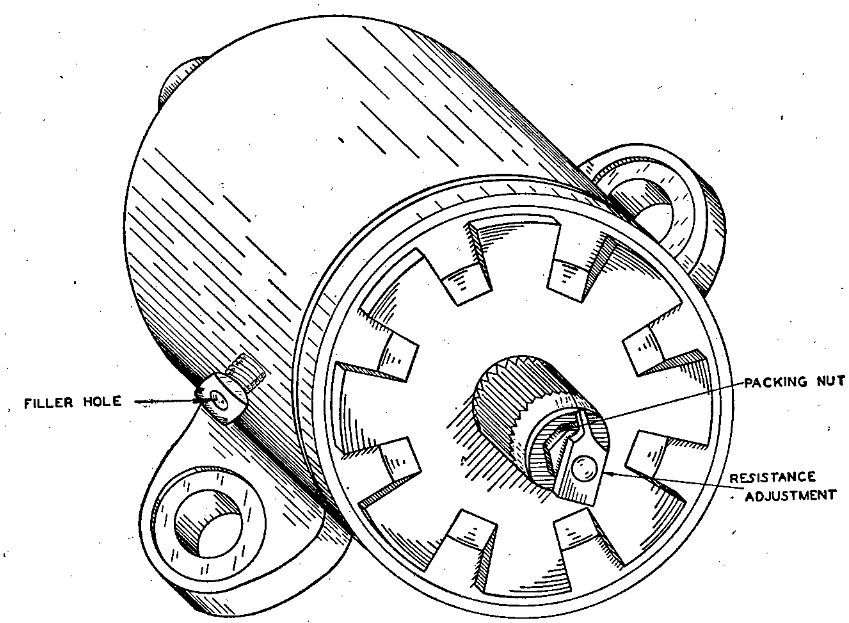


FIGURE 72.—Slip-stream simulator (hydraulic).

shaft to which a lever arm is clamped. The adjustment is located in the end of this shaft in the form of a rectangular "head" or "nut" with an ear on one side bent over to form a pointer. (See fig. 72.) The hex nut, between the adjustment and lever arm, holds in place a packing to prevent leakage around the valve shaft.

c. These units should be checked for any lost motion in the link rods to the controls, for the degree of stiffness, and for leakage. The stiffness is controlled by means of the resistance adjustment shown in figure 72. This figure also shows the packing nut. If this nut is too tight, it will cause excessive friction and a slight jerkiness at the start of movements. It is seldom necessary to refill

the unit. If fluid is required, it should be filled to the bottom of the filler hole. Use only No. 500 shock absorber oil.

18. Main (banking and pitching) bellows.—*a.* The banking and pitching bellows are made of four pieces of wood (top, two middle sections, and bottom) and are covered with rubberized fabric. (See fig. 73.) Four of these bellows are used with the bottoms fastened to the revolving platform and the tops fastened through a linkage to the bottom of the trainer fuselage. Two of the bellows are for banking and two for pitching. Several holes are in the top of each bellows covered by a flap so that if a bellows is pushed together when no vacuum is being applied, the air can escape and damage is prevented. These flaps are stretched tightly over the holes forming an airtight escape valve.

b. It is recommended that the patching cement used for patching all bellows be of a type that will not dry hard, become brittle, and crack. Use a type such as "Stix," manufactured by the Cardinell Corporation, Montclair, New Jersey, which remains flexible even after thoroughly drying. Both surfaces must be clean and dry. Each surface should be given a coating of cement and allowed to stand at least 20 minutes, preferably over night. A second coat should then be applied to each surface and the patch pressed down smooth. The trainer may then be turned on immediately; the vacuum will help hold the patch in place while it is drying.

c. The link bolt from the bellows, extending through the fuselage floor, is secured by a half-round nut and the hex lock nut, forming the universal joint in conjunction with the bellows hook-up sockets. (See fig. 73.) On the hook-up bolt below the hook-up socket, are two additional nuts used to adjust for the effective length of that bolt. The two bottom nuts, the half-round and its locking nut, should be adjusted so that, when the trainer is in its fullest banked or pitched position (turbine off), there will be approximately ¼-inch play in the hook-up socket. This play is necessary to insure proper universal action of the hook-up socket, to prevent bending and breaking of the bolt, and to prevent the possibility of the bellows being pulled from its seat in the octagon.

19. Turning motor, belt, and belt tightener.—*a.* The air motor used for turning consists of two distinct motors, each with five double bellows connected to a crankshaft by connecting rods. (See fig. 74.) The crankshafts of both motors are geared to the same reduction gear unit terminating on a pulley for a round belt. Each motor is connected to the two-way air valve so that by applying right rudder, the vacuum supply is vented to one of the banks, causing the trainer to

turn to the right. Left rudder feeds the other bank and turns the trainer to the left. While one bank is under vacuum, the other motor is idling, being connected to atmosphere through the rudder valve.

b. Referring to figure 75, it may be seen that when the rudder valve is rotated, placing the left motor under vacuum, the vacuum is applied through the hose and elbow at the point labeled "Vacuum duct." In the case of the top pair of bellows, with the sliding valve in the position shown, it may be seen that the vacuum is applied to the top bellows of this pair through the sliding valve, thus evacuating the

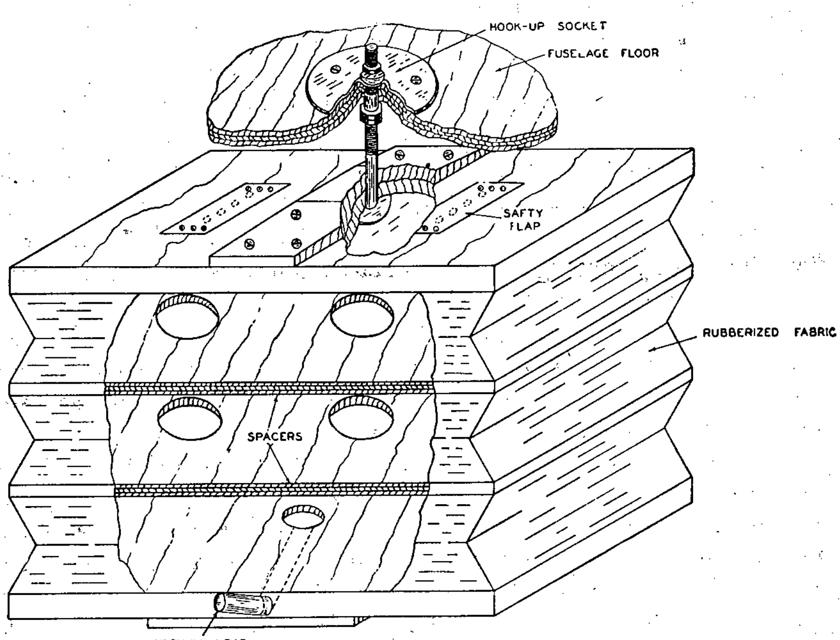


FIGURE 73.—Main bellows.

atmosphere from it and thereby permitting outside atmospheric pressure to collapse it; in so doing it transmits its action by the wooden connecting rod to the crankshaft of that motor, turning it and its pinion gear.

c. The rear bellows of this pair is vented directly to atmosphere at its port in the valve seat, until such time as "firing" of the other bellows moves the crankshaft, and ultimately the sliding valve, over this port and vents the bellows it serves to the source of vacuum.

d. The other four pairs of bellows "fire" in such a manner, according to the proper timing of the sliding valves, so as to give a smooth, variable (controlled by the amount of vacuum applied) movement of the crankshaft.

e. The connecting rods, sliding valves, and valve seats are made of hardwood impregnated with beeswax to eliminate all moisture from them and thus prevent warping. The sliding valves and seats have powdered graphite rubbed into the sliding surfaces for lubrication. This lubrication is accomplished by dismounting the entire motor

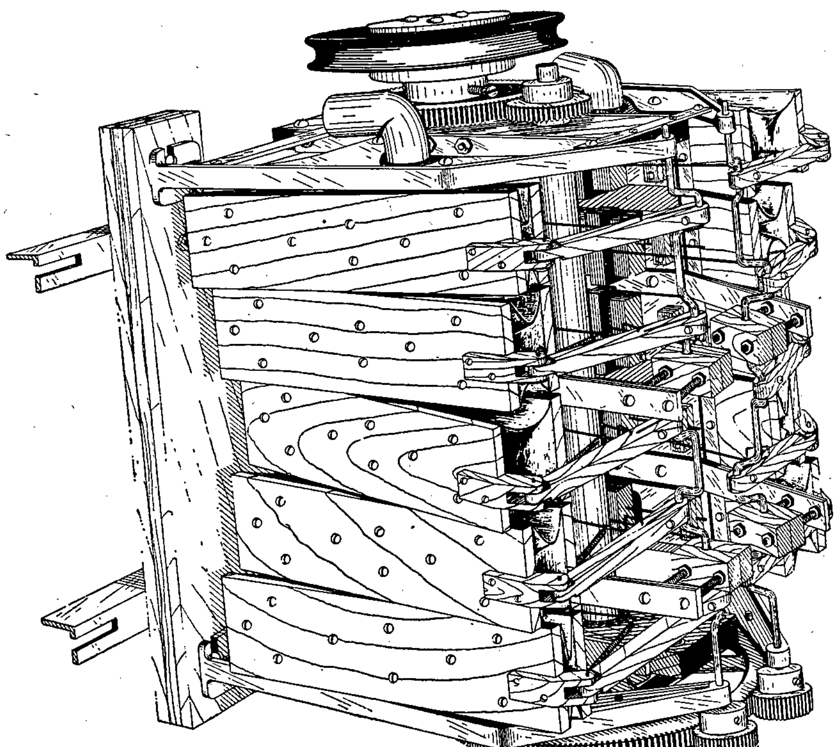


FIGURE 74.—Turning motor—front view.

from its brackets, placing it on a convenient table and further disassembling it by removing the two banks from the motor frame. Since the sliding valves are fitted very accurately to their respective seats, it is recommended that they be removed *one at a time* to prevent their being placed back on the wrong seat. To remove these valves, remove the small leather nut (A) (fig. 76), release spring (B) which is provided to keep the sliding valve on the seat when the motor is idling; remove valve push rod (C) from the hardwood connecting rod; remove valve guide blocks (D) and lift the valve off its seat. Dip a dampened cloth into powdered graphite and rub it into the wooden face of the valve and valve seat until a thin coating of graphite covers the entire surface.

f. Reassemble this unit and proceed with the remaining valves, one at a time, until all are lubricated. Upon reassembly of each motor, turn the pinion gear by hand several revolutions both ways, thereby blowing off excessive graphite that would ordinarily be drawn through the trainer's vacuum system and foul the various valves. *Under no circumstances* are oil or grease to be used on these valves. Graphite weekly or after 50 hours of operation, whichever occurs first; oftener if squeaking occurs, or if wood shows through the graphite.

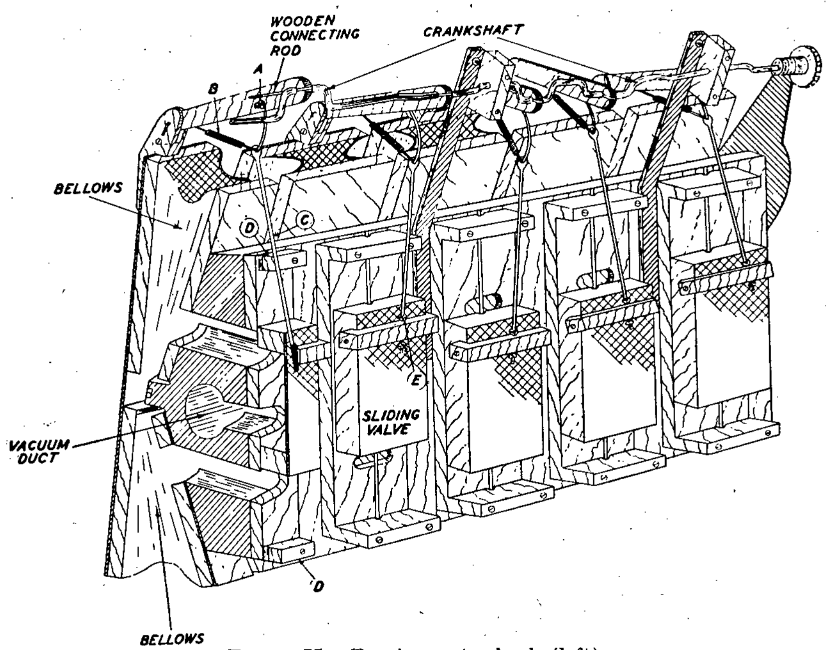


FIGURE 75.—Turning motor bank (left).

g. Timing of the opening of the slide valves is done with the two leather or composition nuts (E) which position the slide valve yoke or the valve rod. The valve should start to open, and the bellows fabric start to move just as the connecting rod passes dead center. This adjustment should not be disturbed while graphiting valves.

h. If wear occurs in the connecting rods, remove the screw (A) and thin washer (B) (fig. 75). Washers of the proper thickness can be made of standard brass shim stock. ***Caution:*** Make sure there is absolutely no bind, as even a slight amount will cause uneven running of the motor. It is better to have the rods too loose than too tight. If squeaking occurs on the bearing of these rods, a single drop of oil may be applied. The gears should be greased lightly as needed.

Ball bearings are of the sealed type and do not require lubrication. *Do not let any oil get on the bellows.*

i. The turning belt is of laminated leather construction, the laminations being held together by marine glue and small screwlike brads. This belt is ½ inch in diameter and approximately 8 feet long. Its length varies with its age. New belts are ordinarily tight, but due to use, stretch considerably. The belt tightener provides a means of changing the effective length of this belt; however, overstretched belts sometimes exceed the limits provided by the belt tightener to such an extent that the belt must be cut off in order that the correct tension may be maintained. Belts are provided

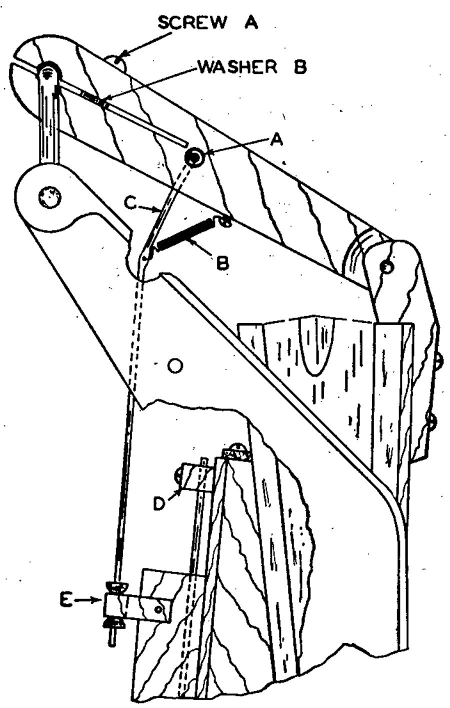


FIGURE 76.—Turning motor bellows connecting rod.

with two types of fittings for joining the two ends. (See fig. 77.) The older type consisted of two small metal links secured, one on either side of the belt, by two rivets. The later type consists of a socket and hook arrangement screwed to the belt ends. The belt should be kept clean at all times so that the correct slippage for "coast" may be realized. If the belt becomes dry and brittle, it may be treated with neat's-foot oil.

j. The belt tightener (fig. 78) is provided so that the correct tension may be kept on the turning belt at all times. The correct tension, arrived at by moving the belt idler pulleys on the two supporting bars, should be such that the motor will turn the trainer promptly, loose enough so that some coast or slip occurs when opposite rudder is applied to change a turn from one direction to the

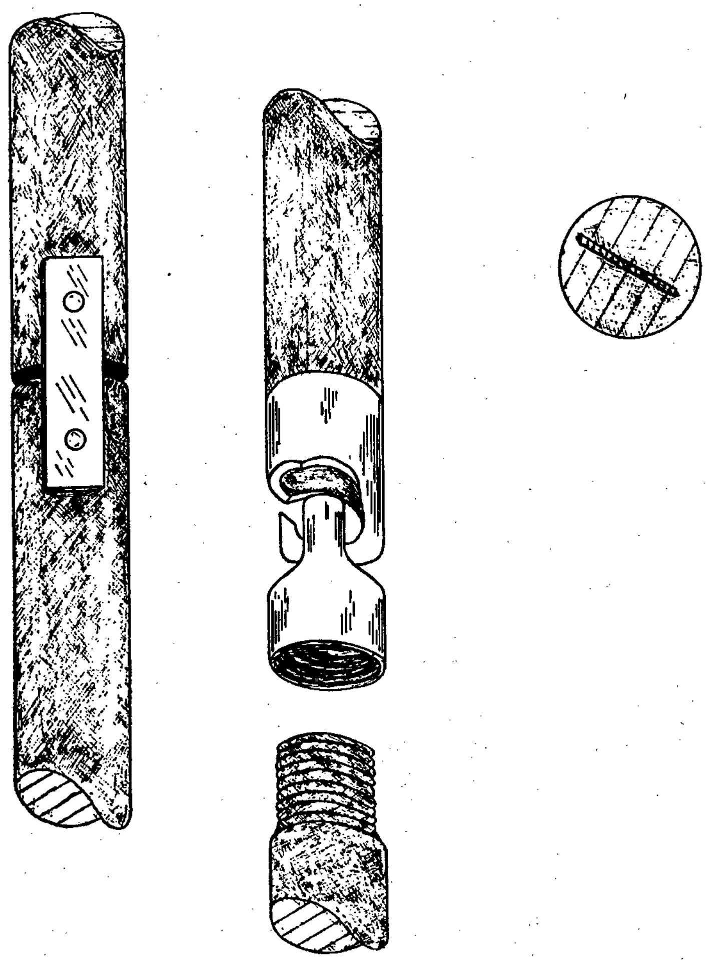


FIGURE 77.—Turning motor belt and belt joiner.

other. The coast should be approximately 45° when applying full opposite rudder from a full rudder turn, the trainer locked in its straps. Adjustment is made by loosening the hexagonal nuts on top of each idler and moving them in or out from center until the correct tension is arrived at. After making the adjustment, check to see that the idlers are equidistant from the side angle iron sup-

ports. If they are not, a turn with the same application of vacuum to the right (or left) may be faster than one in the opposite direction. Lubricate the pulley shafts of this assembly every 50 hours with a good grade of medium oil.

20. Rough air mechanism.—*a.* This mechanism upsets the balance of air in the pitching and banking bellows and turning motor by periodically opening and closing cam-operated flap valves, actu-

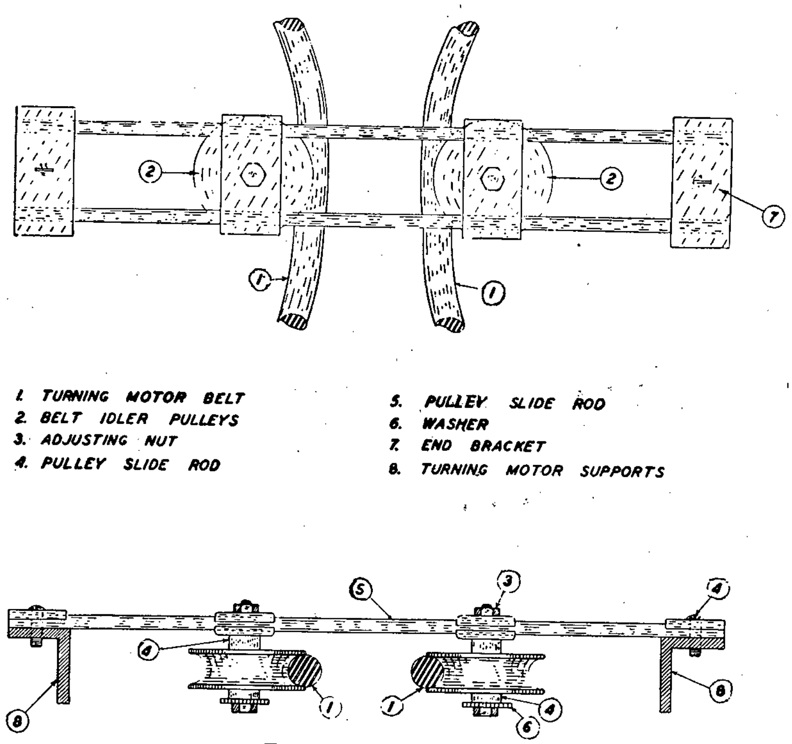
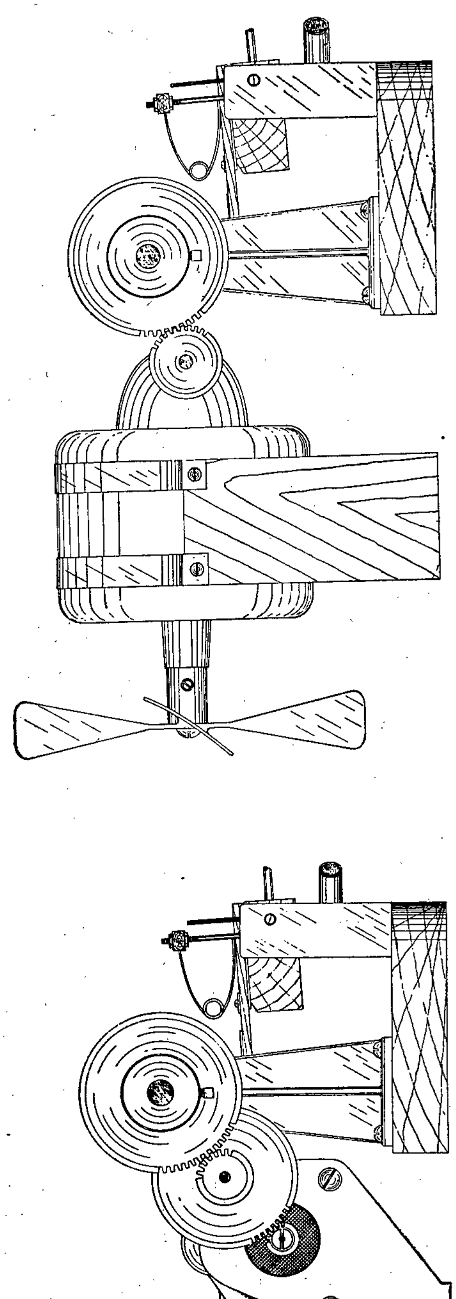


FIGURE 78.—Belt tightener.

ated by the rear fan motor in early models and by a special motor on very late trainers in which the rear fan motor has been eliminated. (See fig. 79.)

b. When the trainer is flying in any given attitude, the banking and pitching bellows are pulling down equally. When one of the rough air flap valves is opened by its cam, a leak is introduced in the main bellows to which the flap valve is connected. This weakens the pull of that bellows and allows the opposite bellows to pull one side of the fuselage down; thus, a lateral or a pitching bump occurs whenever the corresponding rough air flap valves open. (See fig. 80.) Turn-



① New type. ② Fan motor.

FIGURE 79.—Rough air mechanism drive.

ing bumps are arrived at differently. Due to the overlap built into the rudder valves, a small amount of vacuum is constantly applied to the tubes leading to the turning motor. This vacuum is normally allowed to escape through two of the rough air flap valves that are ordinarily held open. When one of these valves is allowed to close, the vacuum which has been escaping is applied to one bank of the turning motor, causing the trainer to yaw. Briefly, the aileron and

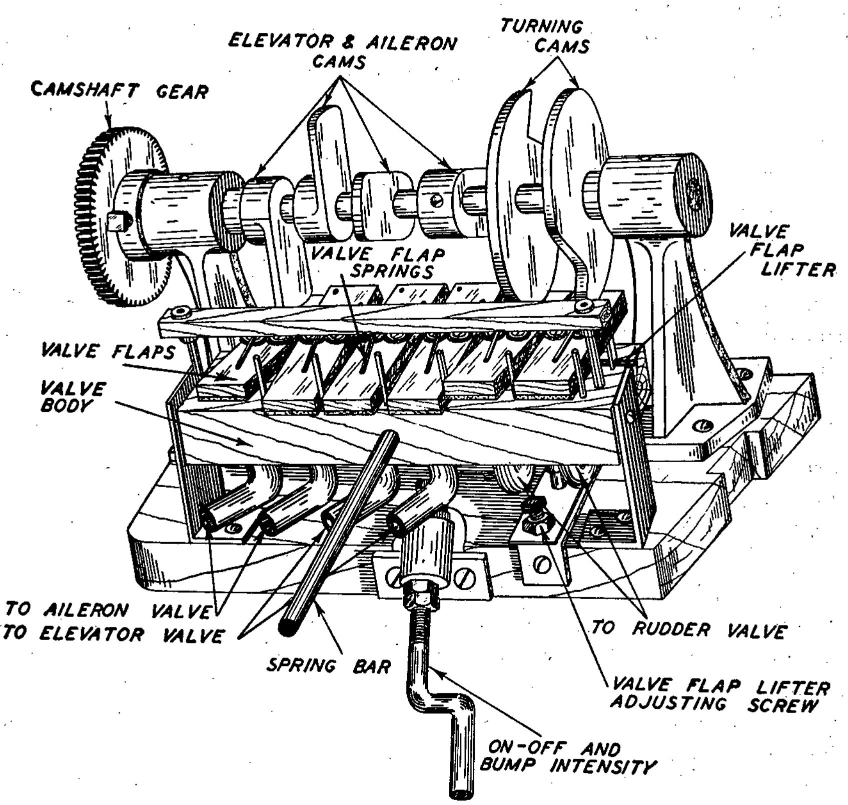


FIGURE 80.—Rough air mechanism.

elevator flaps cause a momentary leak to atmosphere while the rudder flaps shut off a constant leak momentarily.

c. The rough air is turned off and on by means of the crank attached to the rear side of this mechanism. Screwing in on this crank allows the valves to lower so that the rear portion of the flap valves will come in contact with the rotating cams. This crank and its adjustable stop nuts serve also as an adjustment for the proper opening on the elevator and aileron flap valves ($\frac{3}{16}$ inch).

d. Under the rudder bump valves is a T-shaped push rod that holds these two valves off their seats when the rough air mechanism is turned off, permitting the necessary leak to atmosphere into this system. Located on the base block of this unit, directly below the rudder flaps, is a small setscrew that by lifting or lowering a small base plate that the T-bar rests on, serves as the adjustment for the proper $\frac{3}{16}$ inch opening of the rudder flap valves when the unit is turned off.

e. The individual cams serving the flap valves are attached to the cam assembly torque shaft by setscrews thereby permitting adjustment to them. Ordinarily the first two, from left to right, aileron cams are placed 180° apart, thereby excluding any possibility of their opening the two flap valves at the same time, which would result in no aileron bump occurring. The second set of cams serve the elevator flaps which are also 180° out of phase with each other and at right angles to the aileron set. The rudder cams are notched cams that hold the flap valves open for approximately 270° of their rotation and then for the other 90° permit them to close, causing the momentary interruption of the constant leak.

f. The flaps themselves are small oblong wooden blocks, faced on the valve side with chamois and on the rear top side with a brass plate for the metal cams to work on. These flaps are each provided with a small expansion spring to return them to their normal closed position when the cams permit.

g. The vacuum elbow connections located on the bottom of the valve block vary slightly. The aileron elbows are unrestricted leads of approximately $\frac{5}{16}$-inch inside diameter while the elevator and rudder leads are plugged, leaving an opening of $\frac{1}{8}$ inch. These plugs provide the necessary restriction for simulation of the difference in rough air bumps, banking bumps being much more violent, due to the exposed plane area, than are pitching and turning bumps.

h. Lubrication of this unit is very simple, consisting of providing medium oil for the bearing surfaces of the cam assembly and a very thin coat of oil, if squeaking occurs, on the flap-cam plates. The cam shaft gear and motor gear should be kept clean and lubricated with light grease while the motor itself should be oiled with a very light oil on its bearing surfaces. The older type rough air and rear fan motor is provided with a lubrication well and wick arrangement for its front bearing. Keep this unit filled with a good grade of very light grease.

21. Bank turner; spin-trip assembly and spin valve.—The spin-trip assembly is a mechanism provided in the trainer to cause turn-

ing motion to occur independently of rudder action, simulating automatic turn and spin.

a. Automatic turn.—(1) Automatic turn is made possible by the action of this unit which rotates the rudder valve causing the turn to take place; while the automatic spin utilizes the spin-trip assembly as a part of the train of action that occurs preceding a spin. Since automatic turn with bank is more nearly a complete function of this unit than is its part in the spin, automatic turn is covered first. This unit is rather complex in its make-up, so for instructional

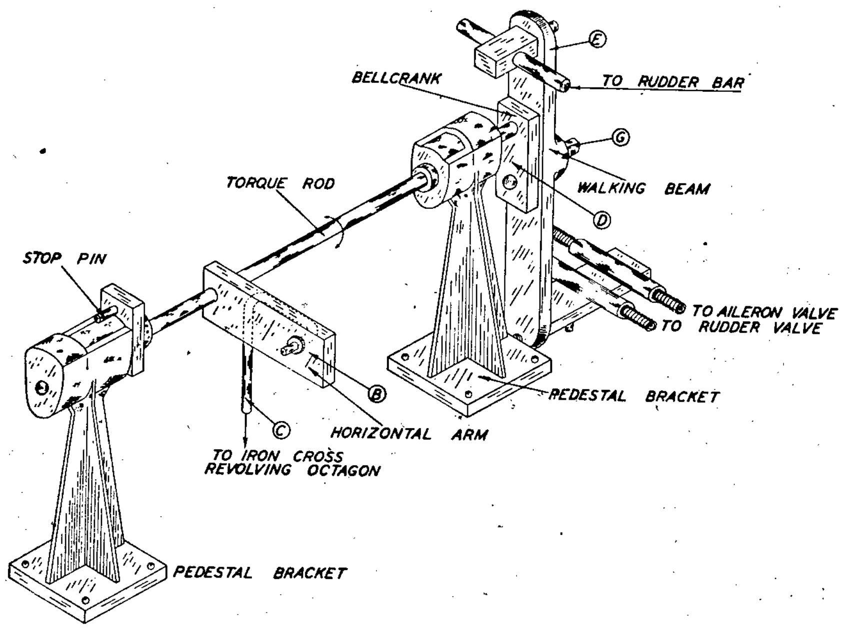


FIGURE 81.—Bank turner.

purposes, illustrations such as figure 81 will be used to show the action that takes place schematically.

(2) Figure 81 shows the horizontal arm (B) attached directly to the torque rod of this assembly. Actually, it is attached to the torque rod by means of a hollow torque rod through a latching mechanism to a second latching arm (H) (fig. 82) that is fixed to the main torque rod. However, whenever the latching assembly is in its normal position (latched) the action is the same as if it were attached directly to the main rod as shown.

(3) This unit, located on the fuselage floor, is on a line parallel to the plane of the lateral axis with the link rod assembly attached to the iron cross of the octagon to the right of the plane of the longitudi-

nal axis, directly on the plane of the lateral axis. From this it may be seen that pitching action, movement of the trainer about its lateral axis, will have no effect upon this unit, due to the point of connection to the iron cross and the universal action of the rods hook-up stud. However, movement of the fuselage about its longitudinal axis, bank, varies the distance between the fuselage floor and the octagon and in so doing, in effect, moves the horizontal arm (B) up or down in respect to the fuselage floor. If the trainer is banked to the right it should start automatically a turn in that direction. Following the diagram (fig. 81) it may be seen that the action described below takes

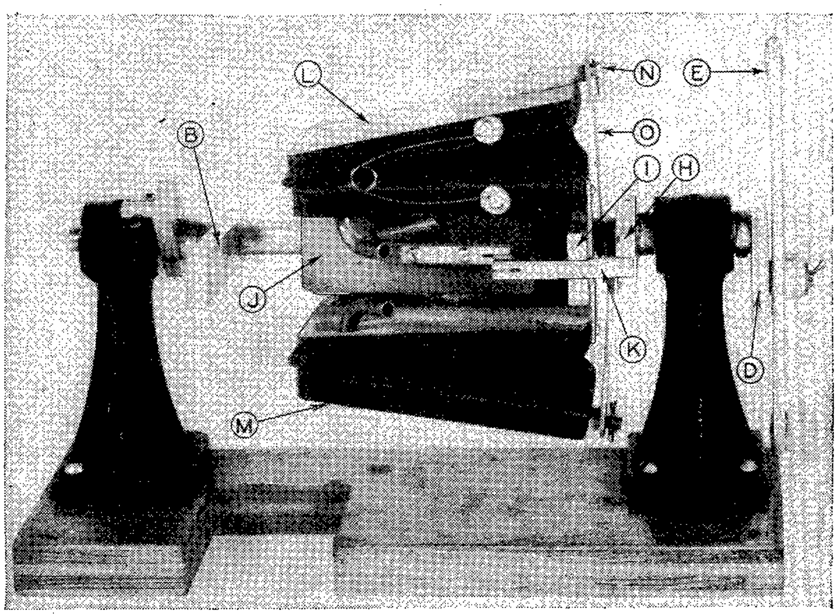


FIGURE 82.—Bank-turner spin-trip assembly.

place when the trainer is banked to the right without application of rudder in either direction.

(*a*) First, the distance between the floor and octagon is lessened, resulting, in effect, in an upward motion of the horizontal arm (B) which in turn rotates the torque rod in a counterclock motion, moving the bottom of the bell crank (D) to the rear, and since the top of the walking beam (E) is stationary due to the fixed condition of the rudder bar, it pivots at this point and imparts motion to the rudder valve by way of the spring compensator link rod, in a clockwise manner, resulting in a turn to the right, the rate of turn depending on the de-

gree of bank. A left bank will effect a turn to the left by reversing the motions of the various parts.

(*b*) If the trainer is not banked, or is held in a given position short of full bank, the shaft (C) and bellcrank (D) will be held stationary. Any movement of the rudder bar, connected to the top of the walking beam (E) will cause the beam to pivot at the bellcrank point (G) and actuate the rudder valve. If the trainer is banked in one direction and the rudder applied in the opposite, the two movements will cancel out by the walking beam pivoting at the bottom, and as a result no turn will take place. Thus, the position of the rudder valve at any time is the result of the combination of the position of the rudder pedals and bar, and the lateral attitude of the trainer.

(4) A second connection at the bottom of the walking beam serves, by means of a spring compensator link rod, a bell crank and a second link rod, to actuate the center leaf of the aileron valve whenever rudder action moves the walking beam; this feature, explained in connection with the main valves, results in an automatic bank with turn. In future sections automatic bank with turn will be referred to simply as "automatic bank," and automatic turn with bank as "automatic turn."

b. Automatic spin.—(1) Automatic spin is accomplished by means of a bellows and latch assembly mounted on the automatic bank-turn shaft. (See fig. 82.) Three bellows are used—one to work the latch, and the other two to provide energy for actuating the rudder valve when spinning. These parts are mounted on a hollow shaft which is free to turn on the solid shaft of the bank-turner. In figure 82 the arm (B), which is connected down through the fuselage floor to the octagon, is permanently attached to the hollow shaft on which bellows and latch are mounted. Arm (I) which carries the latch, is also anchored to this hollow shaft. Note that arm (H) is secured by a setscrew to the solid inner shaft. As long as the latch is engaged with arm (H) the solid shaft is locked to the hollow shaft and the entire unit functions only to provide the automatic turn feature. When the air speed falls below stalling speed, the stall valve opens a vacuum line that leads to the small bellows (J) which is linked to the latch (K). The vacuum closes this bellows and raises the latch out of the notch in arm (H). The hollow shaft is still held rigid by arm (B) but with the latch disengaged, arm (H) and the inner shaft are free to turn. Of the top and bottom bellows, one or the other is always under vacuum. Assume that at the moment vacuum is applied to the top one. This bellows, then, is trying to close, and when the latch releases arm (H) the following action takes

place: The bellows (L) closes. Through rod (N) and link (O) it pushes arm (H) down, rotating the solid inner shaft. The bell crank on this shaft is swung forward and the walking beam, pivoting at point (E), pulls the rudder valve wide open, causing the trainer to spin. If the bottom bellows (M) had been under vacuum instead of the top one, the same action would have taken place except in the opposite direction.

(2) The purpose of the spin valve is to control the application of the vacuum supply to the upper or lower bellows of the spin-trip assembly. It is simply a two-way valve actuated by its inverted pendulum, which is in turn actuated by gravity or the spring fork of the rudder bar. The inverted pendulum is moved right or left between its stops and in so doing, transfers the vacuum supply from its lead on one side to one of two leads on the opposite side, at the same time venting the lead not vented to vacuum, to atmosphere through one of the two small ports in the top of the valve body. By reference to figure 83③ it may be seen that when the pendulum is to the left, facing the valve, the vacuum port is vented, through the round valve body, directly to the lower spin bellows port and the upper spin bellows port is vented directly to atmosphere.

NOTE.—The atmosphere vents, and leads for them, in the valve body are shown schematically, thus permitting the lower spin bellows of the spin-trip assembly to be collapsed by outside atmospheric pressure and in so doing completely open the lower bellows and actuate the spin-trip mechanism. Remember that one or the other of these two bellows is vented to vacuum and one to atmosphere at all times, but due to the locking arrangement they cannot actuate the mechanism until the stall valve applies vacuum to the center bellows and unlocks the assembly.

(3) If during a spin, the spin valve pendulum is actuated due to opposite application of rudder or banking motion and the air speed is not sufficiently high to actuate the stall valve, which places the locking arm attached to the center bellows of the spin-trip assembly in its normal position, the application of vacuum and atmosphere to these bellows will be reversed (fig. 83①), and opposite rudder valve action will be caused.

(4) To recover from a spin in the trainer it is necessary to nose down—to regain normal air speed—and apply full opposite rudder. When the normal air speed is recovered, the stall valve shuts off the vacuum to the small bellows. This bellows then expands (pulled open by springs) and returns the latch to its locking position. Full rudder is applied which throws the spin valve pendulum over. The opposite spin bellows starts to collapse, attempting to swing arm (H)

past the latch. The latch now being in its normal position, engages the notch in arm (H) and locks the solid shaft that carries the walking beam, restoring normal rudder control.

(5) By reference to figure 83② it can be seen that by the removal of the screw (A), and the face plate, the valve core may be removed

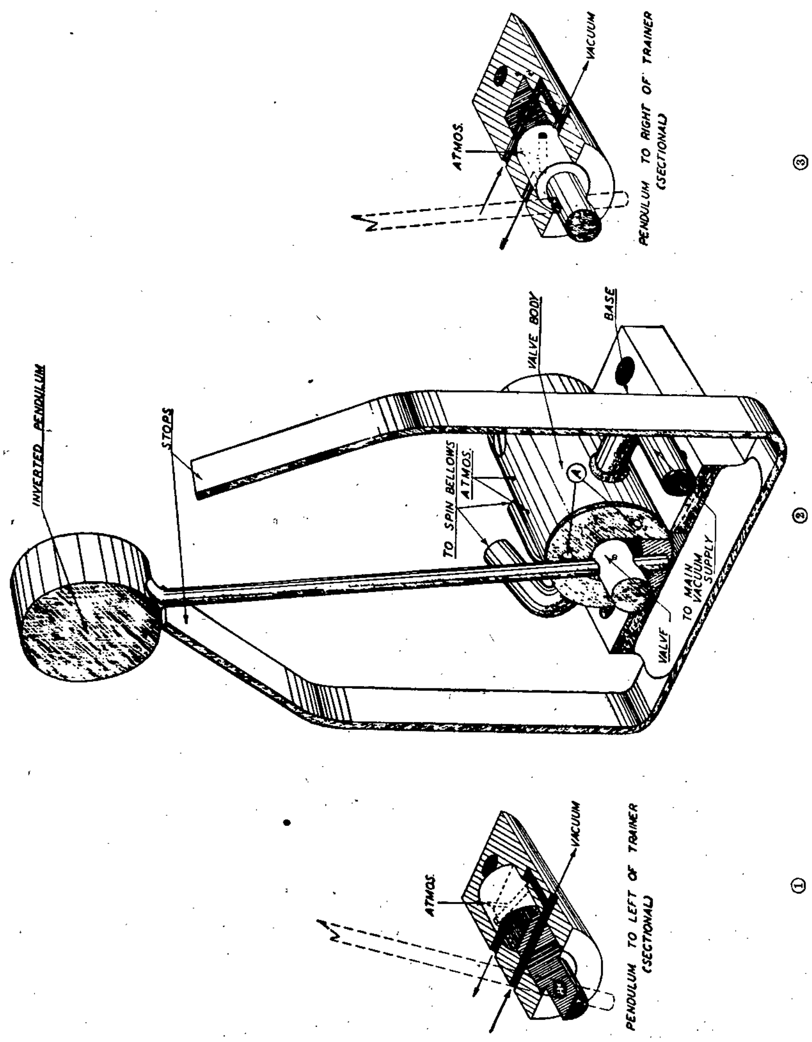


FIGURE 83.—Spin valve.

for cleaning and lubrication. Clean and lubricate with medium oil every 50 hours. The oil not only serves as a lubrication factor, but also to seal the unit. Check daily to see that its action is free and that the rudder bar fork springs are properly alined to actuate the pendulum.

22. Stall valve assembly.—*a.* When the speed of an airplane drops below a certain minimum, the airplane "stalls," and sometimes starts to "spin." This characteristic is built into the trainer and is a function of the stall valve assembly. (See fig. 84.)

b. The bellows of this unit is connected by tubing to the line leading from the air speed regulating bellows to the air speed indicator. Thus, the same vacuum is applied to the stall valve bellows as to the air speed indicator. At normal air speed this suction is strong enough to keep the stall bellows closed (collapsed). In this position (fig. 84), the rod (A) has moved the inverted pendulum (B) to its normal forward position against the stop screw (F). In this position the bellows has overcome the tension of the spring (D). As the air speed is decreased, the suction on the stall bellows is correspondingly reduced. When it is reduced to a certain point, the spring tension is able to overcome the suction and pull the stall bellows open. As the bellows opens, the rod (A) by means of the fingers (E), pulls the pendulum (B) back against the rear stop screw (C). This opens

TECHNICAL MANUAL

INSTRUMENT TRAINER MAINTENANCE

CHANGES No. 1

WAR DEPARTMENT,
WASHINGTON, December 29, 1942.

TM 1–447, September 2, 1942, is changed as follows:

22. Stall valve assembly.

* * * * * * *

d. The trainer should stall * * * the adjusting nut (K). The pin (M) should be set for its original adjustment at approximately $1\frac{9}{32}$ inches from the bottom of the hole in the pendulum arm.

* * * * * * *

[A. G. 062.11 (12–22–42).] (C 1, Dec. 29, 1942.)

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

spread in mph between the first indication of loss of altitude, on the vertical speed indicator, or mush, will be approximately 15 mph

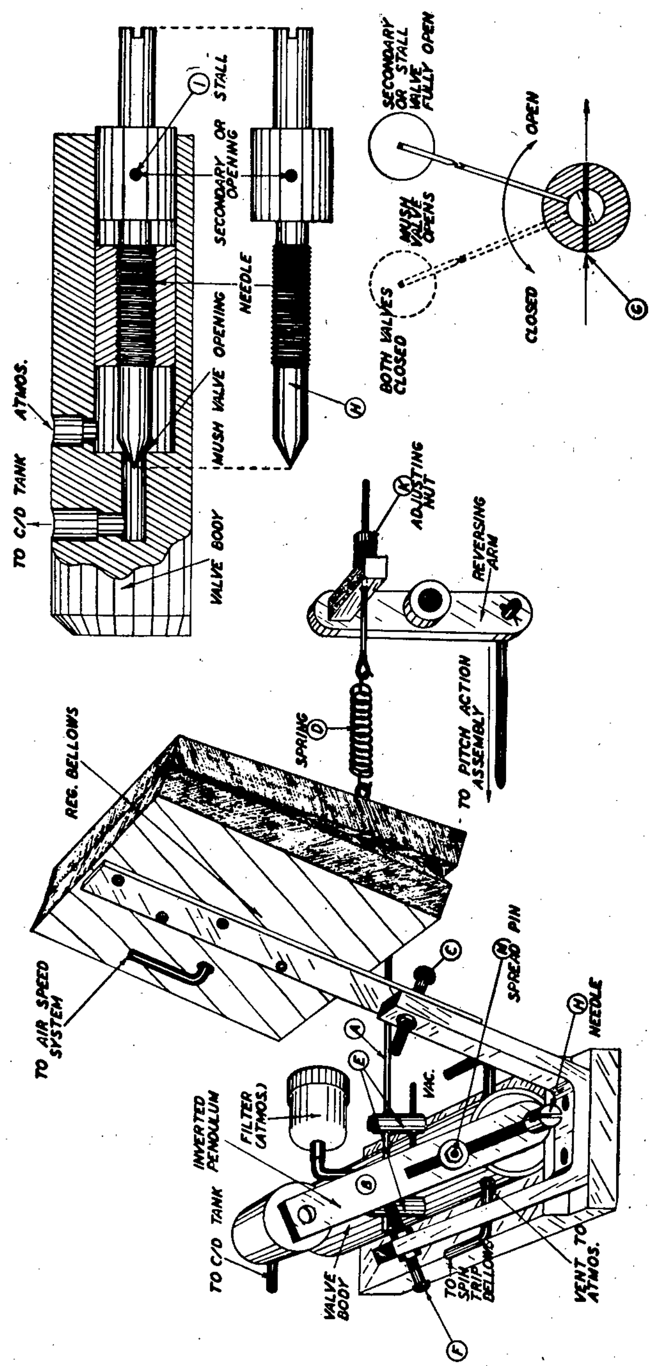


FIGURE 84.—Stall valve.

above the indicated air speed when the trainer actually goes into a spin as the result of the stall valve venting the center bellows of the spin-trip assembly to the supply of vacuum. If the spread is too great, perhaps 25 mph, lower the pin in its slot and test its action. If the spread is not enough, 10 mph, raise the pin and test. These settings are used so the vertical speed will indicate the right amount of mush, spread in mph between mush and stall, and so the trainer will stall at the same speed with closed, cruising, or open throttle. The stalling speed should be adjusted to agree with air speed indications in figure 85. With the trainer locked level, throttle in cruising position, slide front pick-up pin (E) on shaft (A) until

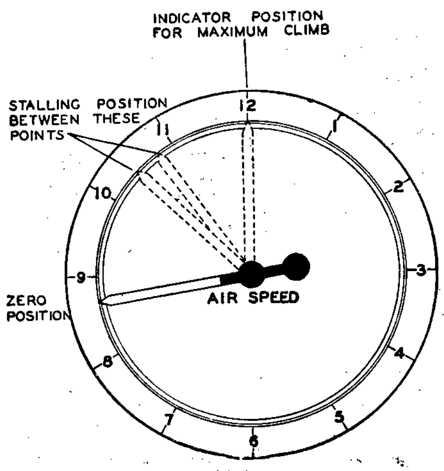


FIGURE 85.—Air speed indications for mush and stall.

the pick-up pin is almost touching pin (M). Unlock the trainer and nose it up until the inverted pendulum falls over to the rear stop. At this moment, the position of the air speed indicator hand should be noted. If the position of this hand does not correspond to figure 85 and is too low, at the moment the trainer stalls, move the front pick-up pin (E) slightly forward and test again. Repeat until the desired stalling speed is reached. Next, adjust the stall recovery pin (E) so it just clears pin (M) on the pendulum arm at the exact moment the pendulum arm strikes the rear stop. (This setting is used so the recovery pin will not interfere with the stall.) Next, stall the trainer, by nosing it up at full throttle, and again at closed throttle. The position of the air speed hand at stalling should be the same in both cases as it was when nosed up from cruising speed. If spring (D) has not been tampered with, the stalling speed should be the

same for any throttle position. If this spring has been stretched or damaged, the only remedy is to install a new spring.

NOTE.—The air speed spring must be properly adjusted to the air speed system before the stall valve is adjusted.

f. It will be noted that due to the linkage from the pitch action assembly to the reversing arm, to which the spring (D) is attached, that the spring tension is *increased* when the trainer is nosed down and *decreased* when it is nosed up. This action, on the surface, seems to be quite the opposite of what it should be. However, the stall valve is, in part, inverted pendulum-operated; and since, when the trainer is nosed down, gravity tends to hold the pendulum in its forward position, additional spring tension is necessary to operate it. The reverse is true when the trainer is nosed up; that is, gravity tends to pull the pendulum to the rear; consequently, less tension on the spring is necessary. In short, the purpose of the spring and its seemingly reversed action is to provide the proper tension at all times, regardless of trainer attitude, so that the stall and spin will take place at the same air speed.

g. A clogged needle in the stall valve almost never occurs, because of the filter on the atmosphere inlet (fig. 84). Any effort to take apart and reassemble this valve should be made only by a thoroughly competent and experienced trainer service man. Adjustments of the needle valve part of this unit are properly and carefully made at the factory and should not be disturbed. In the event the needle or seat are judged to be at fault, the entire unit should be returned to the factory or to an authorized repair base.

NOTE.—In manufacture, the spin-trip control part of the valve is drilled after the needle is adjusted. Consequently, any change in the adjustment of the needle will ruin the alinement of the other holes. For the same reason, the stop screws (F) and (C), against which the pendulum rests in its forward and rear positions, should not be changed. These screws are provided for the original factory adjustment only.

h. Care should be taken at all times to see that none of the moving parts of this unit becomes dirty or lacks lubrication to such an extent that would cause uneven action. Lubricate moving parts, except valve proper, with light oil. The vent to atmosphere in the elbow supplying the center bellows of the spin-trip assembly with vacuum should be kept clean and open at all times in order not to retard the opening of the bellows it serves when the supply of vacuum is removed by the stall valve.

23. Throttle assembly.—*a.* The throttle assembly common to all late model trainers, and the unit being installed as a replacement

on older types at overhaul, is of the conventional quadrant type (fig. 86), provided with a friction type tightening nut whereby the assembly should be adjusted so that when the throttle is completely opened or forward and the trainer nosed up to its maximum position, the main spring compensator *will not* tend to partially close the throttle through its linkages in the pitch action assembly.

b. One of the key adjustments is the throttle adjustment for "cruising", made in conjunction with the trainer's attitude, which should be locked level floating in the hook-up straps, and the climb-dive valve assembly. Cruising position may be defined as the position of the trainer in flight, for proper flying position, where the air speed remains at the 3 o'clock position and no gain or loss of altitude results. To arrive at this setting of the throttle, make certain that the trainer is floating in the straps, advance throttle to wide open position and refer visually to the climb-dive valve assembly, retard the throttle to a position where both the lever arms of the climb and dive valves are against the stops indicating that both valves are closed and that no gain or loss of altitude will result through this assembly.

c. A second adjustment to the linkage of the throttle assembly is made in conjunction with the climb-dive valve. With the trainer floating and the throttle fully open, the rod (fig. 86) should be lengthened or shortened so that the vertical speed indicator will indicate approximately 600 feet per minute as the trainer climbs past 1,000 feet altitude. To make the adjustment, disconnect one ball joint from its lever arm and screw rod into or out of both ball joints as necessary. Additional adjustment, if necessary, may be obtained by adjustment to the long control arm, connecting the lever arm and pitch action walking beam. With the throttle fully closed, the rear compensating spring of the climb-dive valve push rod (against the climb valve arm) should be almost fully collapsed.

d. This assembly should be kept clean at all times, and the ball socket connections of the link rods lubricated every 50 hours of operation with medium oil.

24. Climb-dive valve assembly.—*a.* The climb-dive valve assembly (fig. 87) consists of two separate valves mounted and controlled as a single unit by throttle movement or pitching action of the trainer in such a manner as to vent the altitude system to the source of vacuum, creating altitude, or to atmosphere, causing a loss of altitude.

b. In neutral (cruising) position both valves are closed, indicated by the position of the lever arms (D) against their respective stops (I). Due to action transmitted from the walking beam of the pitch

action assembly by means of the spring compensator link rod and the fact that the forward (dive) valve needle has left-hand threads and the rear (climb) has right-hand threads, one valve opens while the other is held closed. Both valves are connected into the altitude system through a secondary manually operated limit valve located at the rear of each valve body.

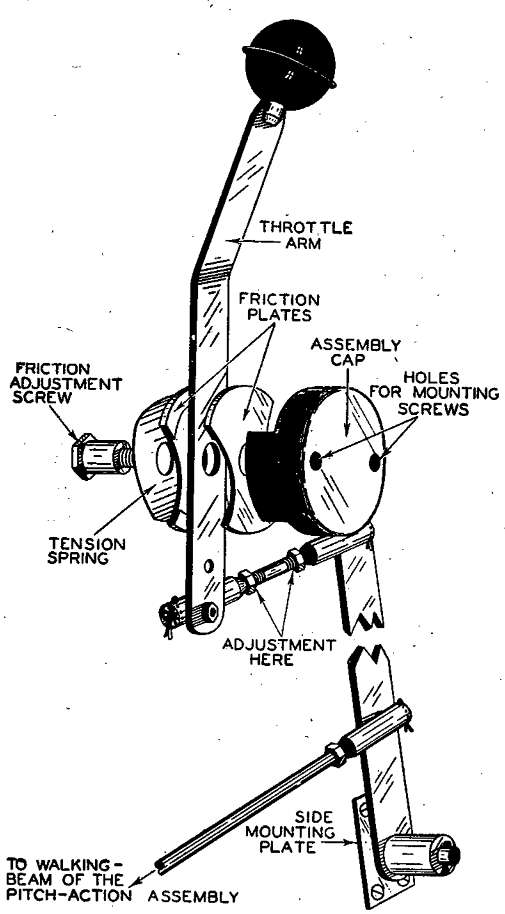


FIGURE 86.—Throttle assembly.

c. These valves are extremely delicate and must be handled with care. The climb valve (A) controls the vacuum applied to the climb-dive (or altitude) tank; the dive valve (B) controls the flow of atmosphere back into the tank.

d. These valves handle very small quantities of air and are therefore critical; and their proper functioning depends on their being

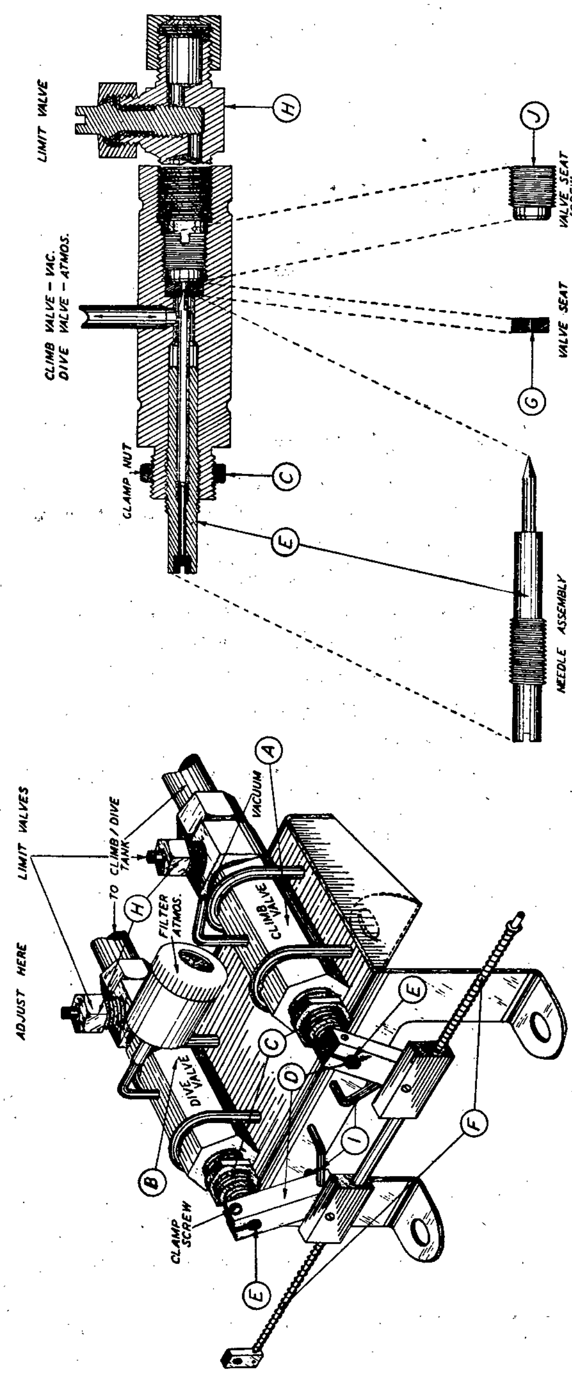


Figure 87.—Climb-dive valves.

in excellent condition and correctly adjusted. They are properly set at the factory and the maintenance man before making any kind of adjustment, should make absolutely certain he thoroughly understands what he is about to do and is sure adjustment is necessary.

e. Each valve has two adjustments: one is the clamp nut (C) to take up any looseness or wear in the threads and the other consists of positioning the lever arm (D) on the needle (E) so that when the arm is against the stop, the needle valve will just be closed.

(1) *Adjusting for wear in threads.*—If side play can be felt in the valve needle, the clamp nut should be drawn up slightly. (Care must be taken to avoid overtightening.) The clamp nut should be tightened one-sixth turn at a time and the valve tested after each one-sixth turn for tendency to bind. To make this test, swing the lever arm away from the stop and let go of it to see whether the compensator springs (F) promptly return the arm to the stop. Continue tightening the nut, testing for bind at each one-sixth turn. When tightened enough so the spring does not promptly close the valve, *loosen* the nut just enough to stop the binding.

(2) *Adjusting needle valve.*—There should seldom be any necessity for adjusting the needle valves and before attempting to do so, the maintenance man should make sure it is necessary. There would be need of such adjustment only when it has been proved that the valve itself actually leaks, or when, due to unfavorable operating conditions, the valve has become partially or completely blocked by foreign matter in the atmosphere and has to be removed for cleaning, which is extremely unusual due to the use of air inlet filters. To adjust the needle valves, the climb-dive assembly must be removed from the trainer, and a manometer or vacuum gage capable of measuring up to 5 inches of mercury will be needed. When a leak is suspected, time and labor can sometimes be saved by disconnecting the copper tubing from the valve and testing with the vacuum gage before removing the assembly from the trainer. In adjusting the climb or dive valve needles, it is imperative that the needle *never be screwed against the seat.* To do so, no matter how carefully, is to risk ruining the valve. The object of the adjustment is to have the needle, in the closed position of the lever arm, just barely reach the seat but not pressing against it. Since it is not practical to screw the needle against the seat (G) to find the closed position, it will be necessary to find, with the vacuum gage, the point where the air flow is cut off. This should be done as follows:

(*a*) Remove the climb-dive assembly from the trainer.

(*b*) Connect a vacuum gage or manometer to the end fitting (H). ***Caution:*** This connection between the valve and the vacuum gage must be *absolutely airtight.* Any leak in this line would give the appearance of a leak in the valve and in attempting to close the valve enough to prevent this leak, the needle would be forced against the seat and the valve ruined.

(*c*) If the leak is slight, proceed as follows: Loosen the clamp screw in the needle valve lever arm enough so it will be holding only slightly. Place a $\frac{1}{32}$-inch spacer, or thickness gage (feeler gage or any object $\frac{1}{32}$-inch thick) between the lever arm and the stop (I).

(*d*) Connect one end of a $\frac{3}{16}$-inch rubber tube to any convenient source of vacuum in the trainer and the other end to the elbow fitting on the valve.

(*e*) Note the rate at which the vacuum gage moves to its maximum reading.

(*f*) Remove the tubing from the elbow and open the valve to allow the vacuum gage to return to zero, then allow the valve to close (arm against stop).

(*g*) Hold the vacuum line *against* the elbow so that the vacuum gage shows 2 or 3 inches of mercury, yet so there is a slight leak between the rubber tube and the elbow.

(*h*) Place the $\frac{1}{32}$-inch gage between arm and stop, and hold the arm from moving. (Clamp, or otherwise secure it, if necessary.)

(*i*) With a small screw driver held *very lightly,* turn the needle about $\frac{1}{100}$ of a revolution in the direction of closing, being careful not to cut off entirely the flow to the vacuum gage.

Caution: The dive valve needle has a *left-hand thread.*

(*j*) Vary the amount of leak between the rubber tubing and the elbow and note the *rate* of movement of the vacuum gage.

(*k*) Continue carefully screwing the needle in, a very little at a time, meanwhile varying the leak between tube and elbow, until the movements of the gage become sluggish.

(*l*) When this point is reached, the rubber tubing should be entirely removed from the elbow to allow the gage to return to zero and then firmly attached to the elbow at each test.

(*m*) When the needle is in far enough so that the full force of the vacuum only moves the gage slowly, tighten the lever arm clamp screw slightly and remove the $\frac{1}{32}$-inch gage and allow the arm to move against the stop. (To return gage to zero, remove suction tubing and open valve for a moment. Then replace tubing.) If the flow of air has been reduced sufficiently with the spacer in place, it will now be entirely cut off and the gage will remain at zero. If, however, there is still a small leak, replace the $\frac{1}{32}$-inch spacer and, proceeding as before,

reduce the amount of leak. To do this, screw in *very slightly* on the needle. With the spacer in place, there still *must continue to be a slight leak.*

(*n*) Remove the spacer and test as before.

(*o*) The final adjustment must be one that shows a leak with the spacer in place and no leak with the arm against the stop. If the valves have been in use for several hundred hours, it is permissible to use a $\frac{3}{64}$-inch spacer to obtain this condition.

(*p*) If the needle has been removed, the valve needle should be given a thin coat of light oil and started in the threads.

(*q*) Connect the vacuum gage as previously outlined.

(*r*) Hold the vacuum tubing against the elbow, varying the leak as before, and screw the needle in with the fingers until the movement of the gage becomes sluggish.

(*s*) Replace lever arm and compensator and proceed as for remedying a leak.

f. If, because of wear or misuse, the needle or seat are unserviceable and it is impossible to adjust them properly, a new set, *needle and seat,* may be installed in the valve body. To do so proceed as follows:

(1) Remove compensator push rods from lever arms.

(2) Loosen lever arm clamp screw and remove from needle.

(3) Loosen needle clamp nut and back needle out of the valve body.

(4) Remove limit valve and with a screw driver remove valve seat screw (J) and shake valve seat (G) from the assembly.

(5) Replace valve seat and needle, always both, never one or the other alone, and adjust as previously outlined.

g. If the maximum climb were permitted to become too great, the mush valve in the stall valve assembly would not be capable of letting air into the system fast enough to show the proper mush during stalls. A plain shut-off type valve (H) (fig. 87), is provided at the ends of both the climb and dive valves to restrict the flow of air to the desired rate of climb and descent as shown in the performance chart. If the maximum vertical speed is not correct, proceed as follows:

(1) Using a screw driver, shut off both limit valves (H) (fig. 87). Unlock trainer and with throttle in "wide open" position, nose trainer up until maximum climbing speed is reached. (Air speed indicator hand at a vertical position.) Keep trainer in this position and open the limit valve on top of climb valve (the one without filter). The altimeter and vertical speed should both show an ascent. Adjust the limit valve until, at an altitude of 1,000 feet, a rate of climb of approximately 1,300 feet per minute is shown. Nose up the trainer several times to make sure that the correct setting is obtained on this limit

valve. Level trainer off at an altitude of 1,000 feet and set the throttle at "cruising." With the throttle set at cruising, the vertical speed should return to zero and the altimeter should remain constant.

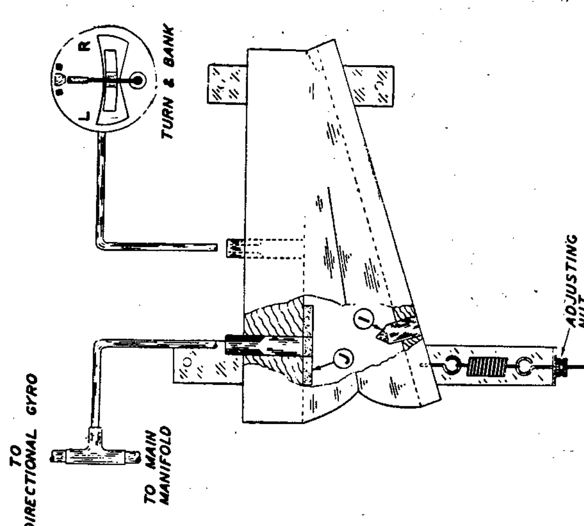
(2) With the trainer level and the altimeter showing a height of 1,000 feet, set the throttle in the closed position and nose the trainer down until gliding speed, three-fourths of cruising speed (120 mph on most trainers) is obtained. Open limit valve on end of dive valve and adjust so that a *minimum* rate of descent is shown on the vertical speed indicator of *800 feet per minute.*

NOTE.—Before any rate of descent can be shown on the vertical speed indicator, the trainer must be flown to some altitude above zero, and at the start of any adjustment or problem the altimeter must be set to a point of at least 500 feet below zero to permit sufficient pressure differential to exist in the altitude system, so that constant and true readings may be had on the vertical speed and altimeter all the way down to *zero altitude.*

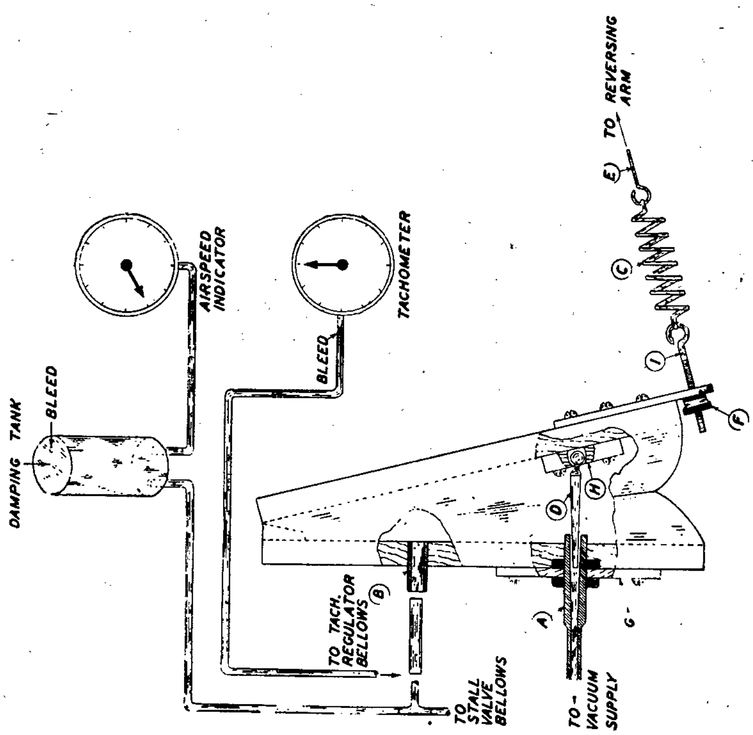
h. Care should be taken at all times to make sure that the complete assembly is securely mounted to the fuselage floor, and that the push rod (F), with springs, is kept clean and well lubricated with light oil. It is not necessary to lubricate the valve needle at the threads unless a new needle has been installed, or an old one removed; in which case clean and lubricate with lightweight oil.

25. Regulator bellows.—*a.* Regulator bellows (fig. 88) are used to control the amount of vacuum applied to the air speed indicator and tachometer. These regulators are connected through coiled springs to the pitch action walking beam and so cause the effects of nose-up or nose-down attitude of the trainer, combined with the throttle setting, to properly affect the two instruments.

b. Fitting (A) (fig. 88) is connected by tubing directly to the main vacuum supply. (B) is connected by tubing through a small dampening tank to the air speed indicator, or direct to the tachometer. (The bellows are the same for both instruments.) When the trainer is turned on and vacuum applied to the bellows at (A), air is drawn out and the bellows starts to collapse but the coiled spring (C) is tending to hold it open. Air continues to be drawn out until there is sufficient vacuum created to overcome the tension of the spring. As the spring is overcome, and the bellows closes, the needle valve (D) shuts off the supply of vacuum. The dampening tank in the tube to the air speed has a small bleed hole. As air leaks in through this hole the vacuum in the bellows decreases until it can be overcome by the spring, which then pulls the bellows open slightly. The needle valve will be opened only enough to permit the passage of just enough air to balance the leak in the dampening tank, and this condition will re-



② Turn and bank indicator regulator bellows.



① Air speed and tachometer regulator bellows.

FIGURE 88.

main until the pull on spring (C) is changed. The air speed indicator (or tachometer) is simply a vacuum gage and indicates the amount of vacuum inside the bellows. Since the pull wire (E) is linked to the pitch action walking beam, any change in trainer attitude or throttle setting will vary the pull of the spring (C) on the bellows. If, by closing the throttle or nosing up, this spring is slacked off slightly, less vacuum will be needed in the bellows to overcome it. Consequently the air speed (or tachometer) measuring this vacuum will fall back to a lesser indication.

c. With the trainer in "locked level cruising condition," the air speed indicator hand should be in an exactly horizontal position (fig. 89), pointed toward the right. If the air speed reading is low, the knurled nut (F) on the air speed regulating bellows (fig. 88) should be tightened; if the reading is high, it should be loosened. In making this adjustment, the nut should be moved only a turn or two and then released from the fingers to allow the bellows to function and the air speed to settle down again. ***Caution:*** *Do not squeeze the regulating bellows together by hand.* The tachometer is adjusted in the same manner, to the position shown in figure 89.

d. Normally, this is the only adjustment required on the air speed and tachometer; however, for a positive check proceed as follows: With the trainer still "floating" in the locks (this should be checked frequently), close the throttle and note the air speed and tachometer. If the pointer of the air speed drops lower than 10 mph below "stalling position" (fig. 89) or the tachometer falls back to less than "idling position," it indicates the spring is too stiff. If either instrument does not fall back low enough, it indicates a weak spring. The maintenance man should not be too ready to believe the springs are bad, but should carefully recheck all other adjustments.

e. If it is finally proved that either of the regulating springs has become too weak, a new spring must be fitted, by careful stretching, to the individual trainer. To do this, proceed as follows: Put the new spring in place, leaving the adjusting nut well out toward the end of the thread. Next, turn on the trainer and adjust the elevator control until there is absolutely no pull, up or down, on the rear locking strap. This means that the lock must be floating in the hole in the strap so that the strap may be slipped off and on again without any change in the attitude of the trainer fuselage. Then open or close the throttle until the climb and dive valves are both closed (arms against the stops). The regulating spring adjusting nut should now be tightened until the indicator shows exact cruising speed. (See fig. 89.) Next, close the throttle. If the indicator falls back below the proper idling

speed, the spring is too stiff and must be stretched slightly. To do this, remove the spring. Hook one end of the spring onto a nail held in a vise or driven into any convenient board. (See fig. 90.) Place a machinist's scale or rule under the spring and against the nail. Stretch

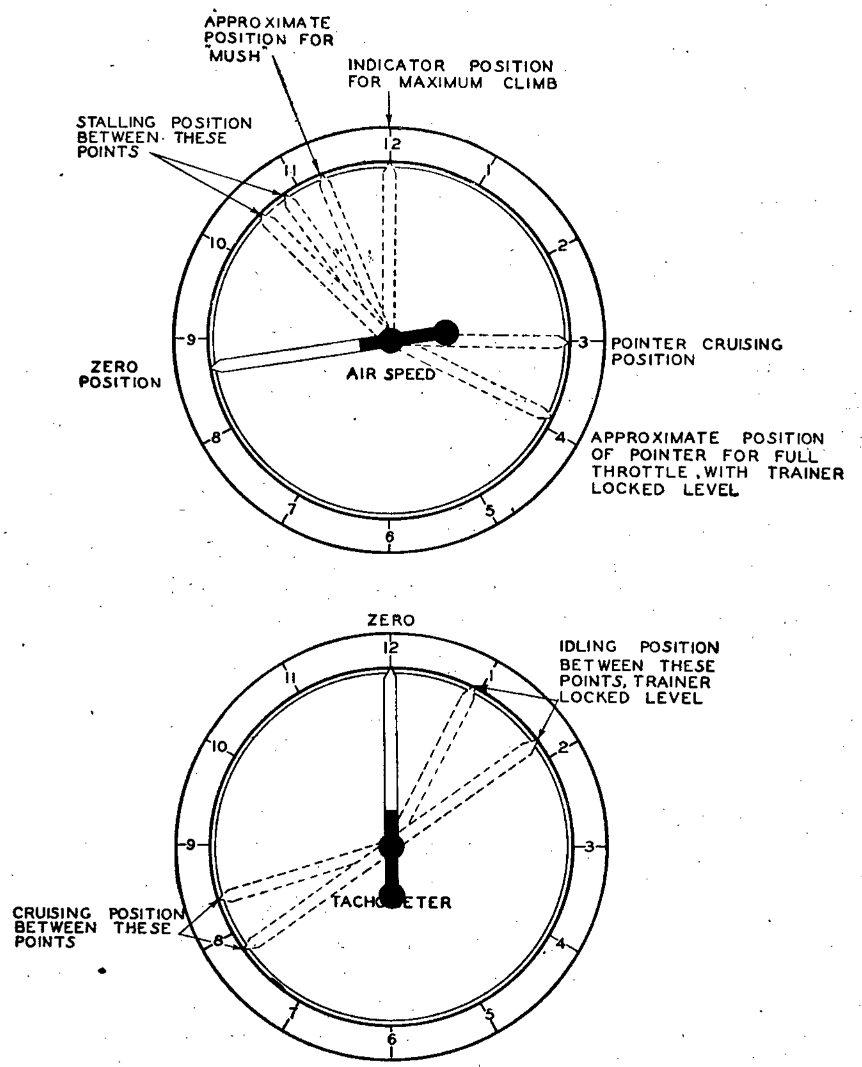


FIGURE 89.—Air speed and tachometer indications.

the spring to a length of about 4½ inches. Replace the spring in the trainer and adjust the nut until the indicator is at cruising position just as was done before. Then check the indications on the instrument at full throttle, and again at closed throttle, against the readings

given in figure 89. The lock strap should be rechecked to be sure the trainer is still "floating" in the lock.

f. If, with closed throttle, the indicator still falls back too low, the spring must be removed and stretched again. This stretch should be to approximately 4¾ inches. Install the spring in the trainer, adjust and test as above. This process must be repeated until the desired indications are obtained. ***Caution:*** As soon as the indicator shows any effect from stretching the spring, that is, it does not fall back quite so low, any further stretching must be done very carefully so as not to overstretch and ruin the spring. At this point, the increase in stretch should be only $1/16$ inch at a time. If the spring has been stretched too much and is too weak, checks 1 and 2 may check satisfactorily, but check 3 will not show enough increase from cruis-

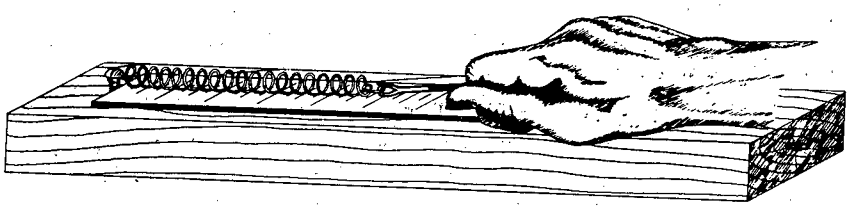


FIGURE 90.—Method of spring stretch.

ing to wide open. Sometimes, if a spring has only been slightly overstretched, a few turns of the coils (not more than three) can be removed to regain the proper characteristics. However, if it has been overstretched, there is nothing that can be done but replace the spring and start adjustments again.

g. Air speed indicators and tachometers on the trainer are so designed and calibrated as to require a certain amount of vacuum to move the pointers certain distances around the dial regardless of the numeral appearing on the face of the instrument. The linkages and regulator bellows are so engineered as to supply just that certain amount of vacuum at any given position of throttle and attitude of trainer. In cruising position—with locks on and climb-dive valves closed—for best results, the air speed indicator pointers must be horizontal at a position corresponding to the "3" on a clock face, regardless of the numeral appearing under the pointer. If it is desired to simulate a different cruising speed than appears under the pointer, it will be necessary to replace the dial. Figure 89 shows the proper position for the pointers at stalling speed, cruising, and full throttle speed with locks on.

h. Maintenance.—Check each day for small holes in the bellows fabric; any leak, no matter how small, will result in malfunctioning

of the system proper and will be apparent by its effect upon other associated systems. Never squeeze the bellows together by hand. To do so will result in damage to the needle (D) and its seat in unit (A), resulting in the needle tending to stick in the seat and then come open with a jerk when sufficient spring tension is applied. A second cause for a sticky needle is a dirty or gummed needle and seat; which condition, should it exist, necessitates the removal of these units for cleaning. To do so, remove the four wood screws that secure plate (G) to the bellows, insert a knife blade between the plate and wooden bellows end to break the glued seal, remove plate, being careful not to bend or ring the needle. Remove the screws holding needle holder (H) to the inside of bellows, remove and clean. If necessary polish needle with No. 0000 sandpaper or very fine crocus cloth, lubricate needle ball socket with a single drop of light oil and reinstall. After cleaning needle seat, replace seat plate only after cleaning plate and applying a good grade of glue for sealing purposes. Allow glue to dry thoroughly before placing the complete unit in service again.

i. Should the pull wire (E) be removed from the air speed or tachometer reversing arms it should be reinstalled so that its effective length permits full adjustment by the adjusting nut (F) on rod (I). Both air speed and tachometer regulator bellows are controlled by the differential linkage of the throttle and pitch action assembly by way of their respective linkage connections to the walking beam. Movement of the walking beam is transmitted through link rods to reversing arms and then by steel wire and the regulating springs to the bellows. As increased tension is applied to the moving portion of the bellows, the needle is pulled out of its seat and permits the flow of atmosphere from that system to the turbine.

j. A third regulating bellows (fig. 88), the turn and bank indicator regulator bellows, performs the same function as the tachometer and air speed bellows, but is controlled manually to a setting that applies the correct amount of vacuum to the instrument it serves. This bellows is not subject to the wear or the necessity for the high degree of accuracy that the other two are, and so is of different construction. The needle itself (I), is formed of wood seats in a chamois seat (J). The manually controlled spring tension opens or closes the bellows and in so doing varies the amount of atmosphere the turbine is permitted to draw through the instrument. Tightening the adjusting nut increases the flow, while untightening decreases it. This arrangement is necessary because of the properties of the instrument being served, and its source of supply which is common to the direc-

tional gyro as well. The latter instrument requires the complete supply of vacuum, while the turn and bank indicator utilizes but approximately half of it.

26. Turn and bank indicator.—*a.* The turn and bank indicator is a precision instrument used for controlling the flight of an aircraft or trainer under conditions of poor or no visibility or when, for any reason, it is desirable to eliminate any yawing or turning motion. Specific uses for this instrument are to enable the pilot to maintain straight and level (lateral) flight and to make precision turns at predetermined rates; and to coordinate rudder and ailerons when making turns.

b. This instrument is a combination of two flight instruments, the turn indicator and the bank indicator. The turn indicator unit is a gyroscopic device which indicates, by means of an indicator hand moving over a calibrated instrument face, motion about the vertical axis of the trainer. (See fig. 91.) The dial is plain, having only the letters "L" and "R", the neutral center mark, and an index on each side of the neutral mark. When the index is covered by the indicating hand either right or left it indicates that a double rate, two-needle width turn at the rate of 360° per minute is being made; however, this type instrument is known as the single-needle width instrument and is used in instrument flying as such. A standard rate turn is one made with the indicating hand exactly one needle width off center or a rate of 180° per minute. (See fig. 91.)

c. The bank indicator or inclinometer is a simple pendulum device comprising a black glass ball which moves against the damping action of a liquid in a curved glass tube in such a manner as to indicate motion about the longitudinal axis. This portion of the instrument indicates that the attitude is or is not level laterally or indicates that the proper bank is or is not being maintained for the turns being made. It in no way indicates the amount of bank. This instrument differs from the standard aircraft turn and bank indicator only in respect to the inclinometer which, due to the lack of centrifugal force in the trainer, is linked directly to the gimbal ring of the gyro.

d. The instrument case is of the standard size, using a 2¾-inch dial, and has incorporated into the case proper a drain plug, vacuum connection, damping adjustment, sensitivity adjustment, and lubrication opening. (See fig. 92.) The drain hole and screw are located on the bottom of the instrument just behind the mounting flange assembly to facilitate the removal of collections of water and oil from the interior of the case. One vacuum connection is located on the bottom rear, and the other at the back of the case. Both have ⅛-inch

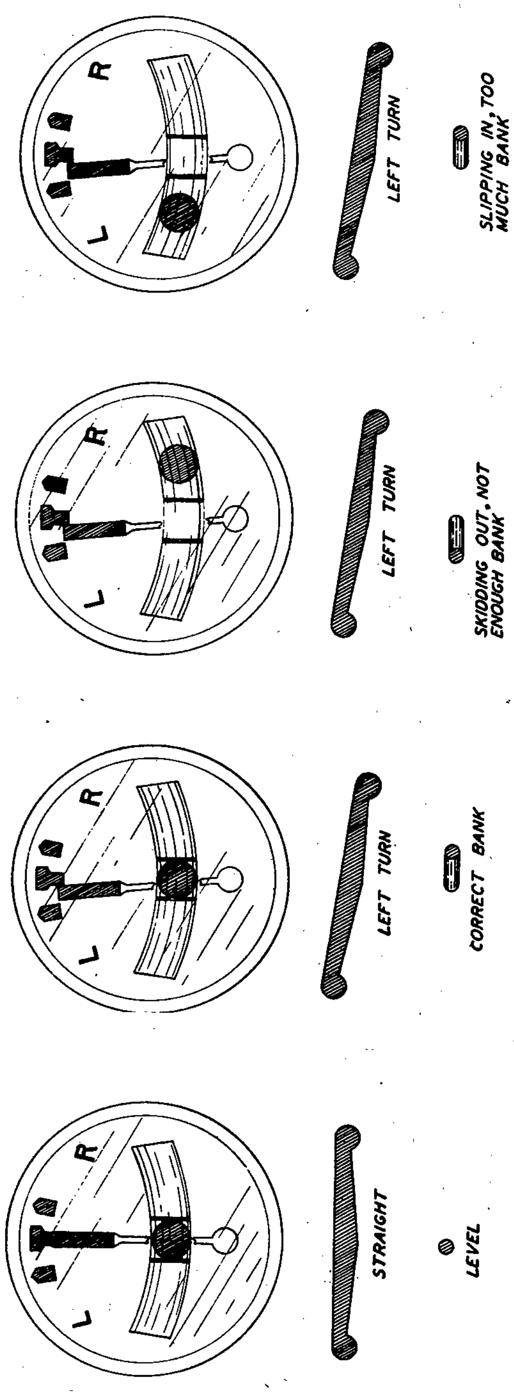


FIGURE 91.—Turn and bank indicators.

internal pipe threads and are provided with a pipe plug so that either may be removed to connect the vacuum line, depending upon convenience of the installation. The damping adjustment screw and lock nut are located on the right-hand side of the case just behind the mounting flange assembly. When this screw is turned "in," the open area of the damping orifice is increased and the damping effects decreased. The sensitivity adjusting screw and lock nut are located on the left-hand side of the case just behind the mounting flange assembly. When this screw is turned "in" the tension on the centralizing spring is decreased, permitting the rate-of-turn pointer to deflect farther for a given rate of turn. The lubricating opening is located on the right-hand side of the rear section of the instrument case and is provided with a threaded plug and a lead gasket for sealing purposes.

e. The bank and turn indicator, grouped with other flight instruments, is mounted so that the dial is vertical when the airplane is in normal flight position and the ball of the bank indicator is in the center position. Before a new instrument or one which has been received from stock is installed, approximately six drops of a mixture of one-third compass liquid and two-thirds gyro instrument oil are added to the rotor pivot.

f. Service maintenance and inspection of this instrument also include the following tests:

(1) *Static balance test.*—The pointer must zero when the rotor is not spinning + or − $\frac{1}{64}$ inch for any position of instrument.

(2) *Dynamic balance test.*—When the instrument is stationary in normal position and the gyro is operated under a suction of 26 inches of water, the pointer should stand at the zero mark + or − $\frac{1}{64}$ inch.

(3) *Starting friction test.*—With the instrument in normal position, stationary, and not being subject to vibration, a suction of not more than 5 inches of water should cause the gyro to rotate.

g. Lubricant is added through a lubricating opening marked "Oil" on the right side of the case after the instrument has been removed from the trainer. A fine wire (approximately .015-inch diameter) should be used to guide the oil into the hole in the pivot. Any excess of spilled oil may be a source of unsatisfactory operation. For operating conditions in which atmospheric temperatures are above freezing (0° C. or + 32° F.), add 8 drops of gyro instrument oil.

h. In testing and adjusting the suction, a source of vacuum is connected to the system at the plug located in the back of the instrument case, or by means of a T-connection in the line serving the instru-

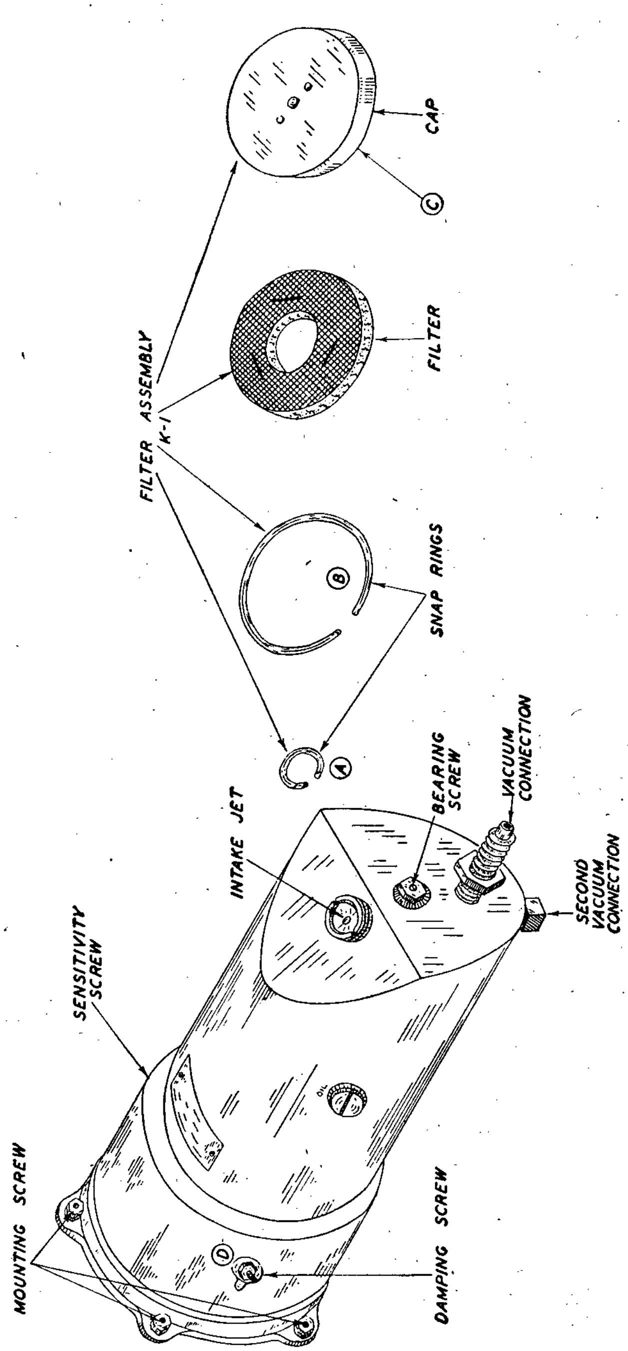


FIGURE 92.—Turn and bank indicator—side view.

ment. The line leading to the instrument from the suction system should have a suction of 3.5 to 4.25 inches Hg. By means of the regulator bellows, the suction on the instrument is adjusted as closely as possible to 1.9 inches Hg. It should never be less than 1.80 nor more than 2.05 inches Hg.

i. The screen and jet may be cleaned by first removing it from the instrument, washing it in carbon tetrachloride, and drying it thoroughly. When reinserting, a wrench is not necessary; finger tight is sufficient. Any condensate and excess oil may be removed by unscrewing the drain plug. All plugs and connections must be tight in order to prevent excessive air consumption.

j. Filter, model K-1.—This unit is designed to remove foreign matter from the air bleeding into the case of the instrument. It should not be allowed to load up with excessive dust and dirt, as this will interfere with the flow of air and slow down the gyro speed, thereby upsetting calibration of the instrument. The filter should be inspected weekly and a new filter installed when needed. Remove the filter assembly from the back or bottom of the instrument, and with the aid of a small screw driver or jackknife, unfasten the snap rings "A" and "B", (fig. 92). The filter unit may then be lifted out of the case "C" and examined to determine whether to replace or to use it again. Under average conditions, the filter unit should last approximately 100 hours. In the event that additional filters are not available, a temporary unit can be manufactured. The old filter can be disassembled, the filter paper removed, and the screens washed with carbon tetrachloride. Replace the filtering agent with any filter paper of the same quality. Place the new filter paper between screens, clip together with paper staples, and trim off excess paper. ***Caution:*** If the paper is too fine, it will interfere with the flow of air and cause improper functioning of the turn indicator.

27. Artificial horizon.—*a.* This is a special instrument of pendulous control and is not gyro operated like the instrument used in the airplane. When shipped, there are two screws locking its moving parts to prevent damage in shipment. To unlock, it is neccessary to remove the rear cover case by loosening knurled nut on end of case. (It is necessary sometimes to remove instrument from panel to be able to remove cover from instrument and to fill small oil dash pots.) Remove the locking screw from the bottom of the instrument, which locks the ball-shaped weight (A) (fig. 94). Then remove the screw from the rear which locks the lateral control pendulum (B). The instrument is then free to operate. Fill the two small oil dash pots (C) and (D) with castor oil. Work the moving parts until

all air is forced from under the dash pot pistons and the dash pot chamber is about seven-eighths full of oil. Before replacing the instrument in the trainer, be sure all moving parts work freely and are not binding or rubbing on adjacent parts.

b. After installation, it may be necessary to level, horizontally, the indicating bar of the instrument. To do this, remove the cover and shift the position of the sliding brass bar (E) at the end of the in-

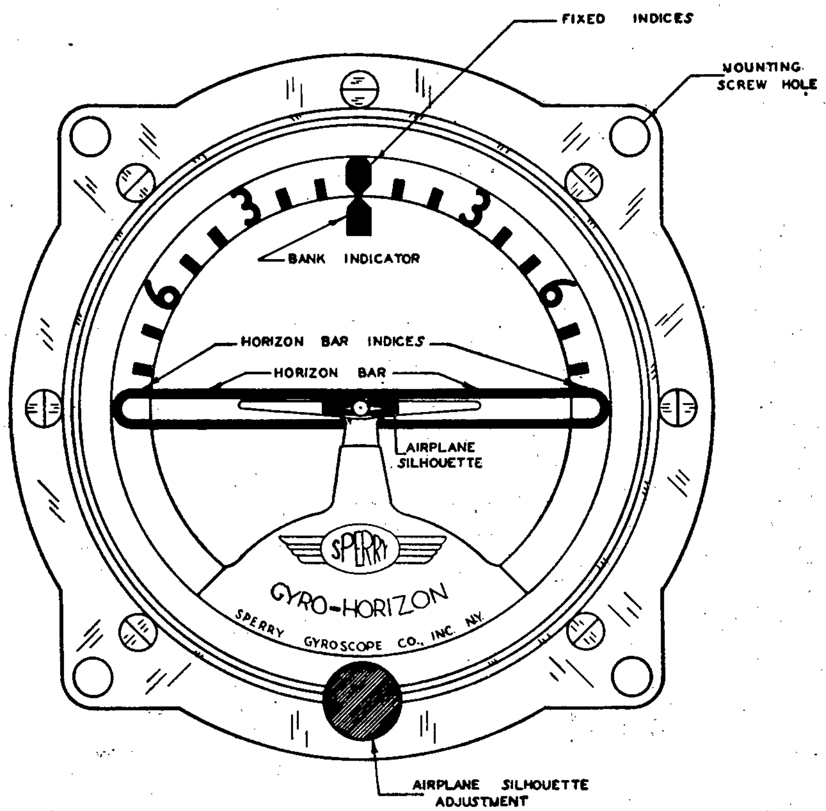


FIGURE 93.—Artificial horizon (face).

strument until the bar is level. To level the horizontal bar with both its side indexes after it has been leveled horizontally, first ascertain that the trainer is locked level floating, then by loosening screw (F) and holding rod (G), move weight (A) on the rod until the bar lines up level with both fixed side indexes. When installation is complete, replace cover to keep out dirt and dust.

c. The instrument should be removed, cleaned, dash pots checked for oil, and all bearings lubricated with gyro instrument oil each 500 hours.

28. Tachometer and air speed indicator.—*a.* These instruments, as used in the trainer, are simply suction gages with instrument faces calibrated in revolutions per minute on the tachometer and in miles per hour on the air speed.

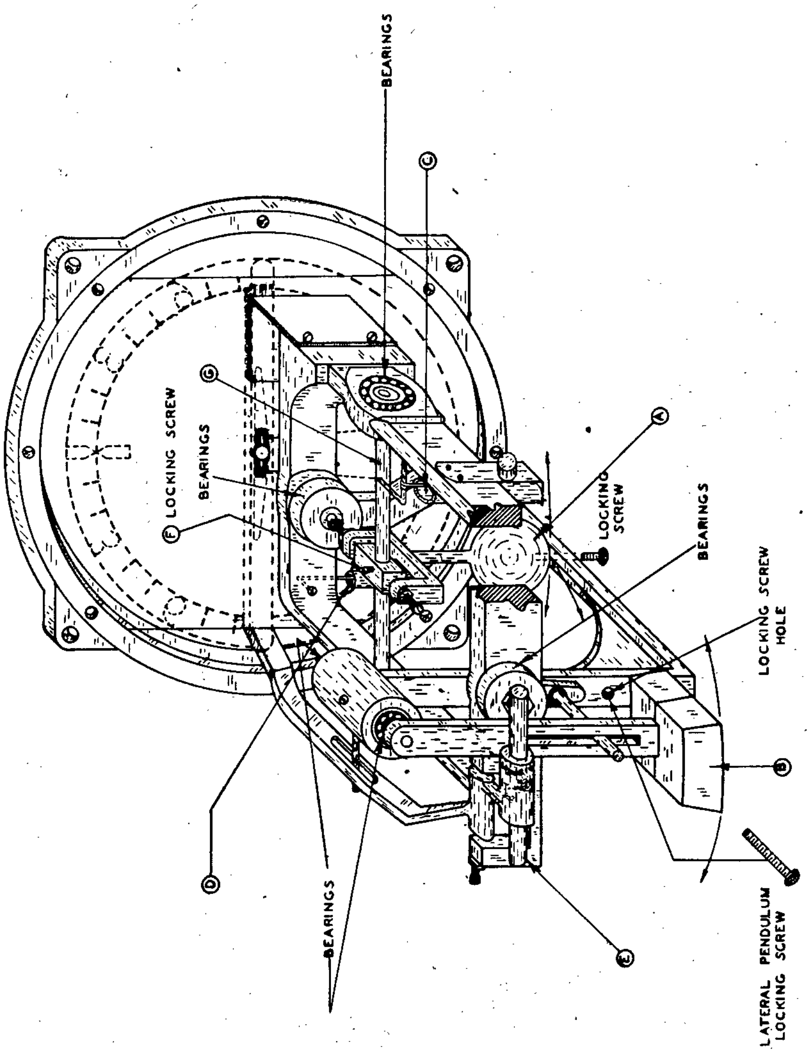


FIGURE 94.—Artificial horizon mechanism.

b. Their mechanism (fig. 95) is identical consisting of a case, vented to atmosphere, within which is a pressure sensitive capsule or diaphragm and a multiplying mechanism which amplifies the movement of the diaphragm and transfers it to the pointer. The suction applied

to the instrument by the regulator bellows is admitted to the diaphragm through a connection in the back of the case. The corrugated faces of the pressure capsule are reacted upon by the pressure differential existing inside of it and the magnitude of deflection of the capsule walls, and ultimately, the pointer movement, depends upon the amount of pressure differential caused to exist by the regulating system.

c. Early model trainers were furnished with air speed indicators so calibrated that the 120 mph mark came at exactly the 3 : 00 o'clock position; however, all late models cruise at 160 mph with the pointer in the horizontal position. The air speed indicator on models C-4, C-5, and C-3 is part of the remote indicating Telegon system and will be covered as part of that system.

29. Magnetic compass.—*a.* The magnetic compass (fig. 96) supplied with trainers is a standard aircraft instrument of the type B (pilot's type) and consists essentially of a nonferrous metal bowl filled with liquid and containing a card element carrying a system of magnetized needles so suspended on a pivot that it is free to aline itself with the meridian of the earth's magnetic field. The indications of the card and the reference line or lubber's line are visible through a glass window of the bowl. An expansion chamber is built into the compass to provide for expansion and contraction of the liquid resulting from altitude and temperature changes. (See fig. 97.)

b. The lighting system provided with compasses on late model trainers is peculiar to that type of trainer only, being either the ring lighting or fluorescent type.

c. Operation.—The earth acts as a huge magnet, with one pole near the north geographic pole and the other end near the south geographic pole. If the bar magnet is so suspended as to turn in any direction about its center of gravity, it will take a position with one end pointing toward the north magnetic pole and the other pointing toward the south magnetic pole. For this reason, the ends of magnets are known as the north-seeking or N-end and the south-seeking or S-end, respectively. Since the magnetic force action on the N-end is equal and opposite to the force acting on the S-end, the effect on the N-end only is considered. The position taken by a freely suspended bar magnet gives the direction of the magnetic force or magnetic north. Thus, the compass is a direction-indicating instrument. However, when installed in an airplane or trainer, it is subject to additional forces.

d. There are four main causes for inaccuracy in aircraft compasses: incorrect installation, vibration, magnetism, and northerly turning error. Aircraft and instrument designers reduce or eliminate com-

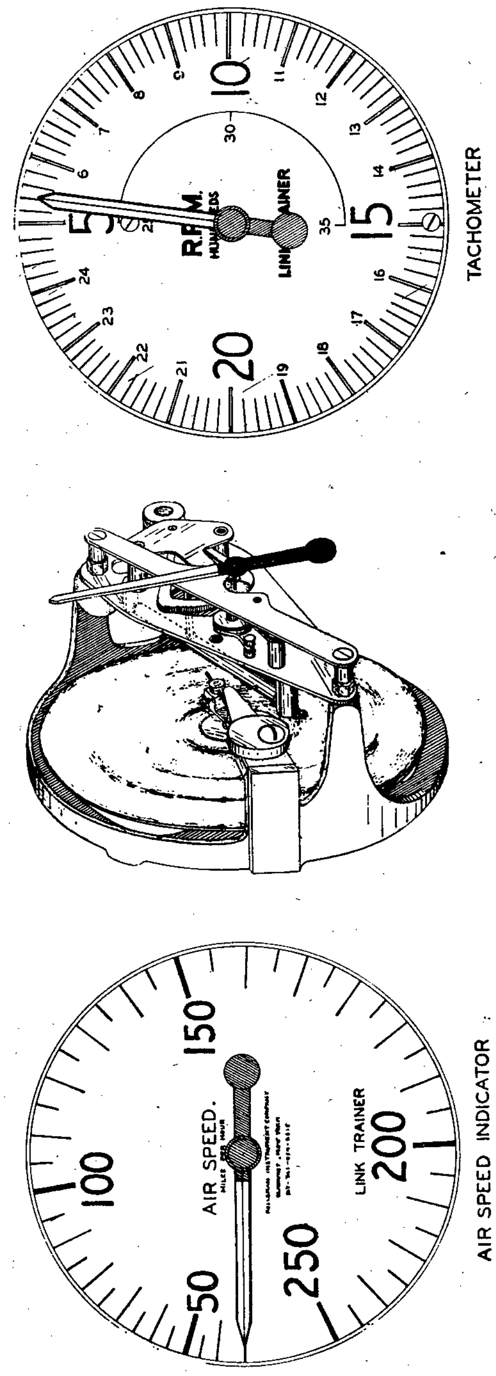


FIGURE 95.—Tachometer and air speed, cutaway, trainer.

pass inaccuracies due to faulty installation and vibration by careful selection of compass location, use of vibration absorption mounts, provisions for level mounting, etc. During the construction of aircraft, the vibration and jarring of steel parts while being forged, machined, or fitted in place, impart a certain amount of permanent magnetism which is induced by the earth's magnetic field. This changing field of permanent magnetism correspondingly affects the action of the earth's magnetic field on the compass and thus causes the compass card to deviate from the magnetic north. Further de-

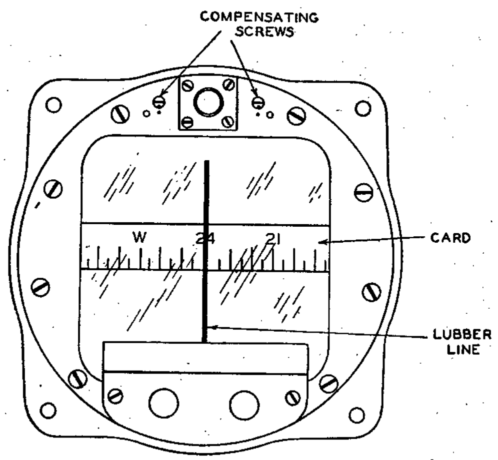


FIGURE 96.—Magnetic compass, type B (face).

viations of the compass result from electric currents flowing in the electrical system of the aircraft, radio equipment, electrical instruments, and from varying positions of metallic masses. Corrections of compass errors resulting from the permanent magnetic influences referred to may, if not excessive, be accomplished within close limits by the proper application of compensating magnets.

e. The error of any compass is the angular difference between true north and compass north, or the angle between the true meridian and a vertical plane passing through the length of the compass needle. Variation is caused by terrestrial magnetism influences and is the angular difference between true north and magnetic north measured from the true meridian. It is termed "west" when the terrestrial magnetism draws the compass needle to the left or west; and "east" when the needle is drawn to the right or east. Deviation is caused by the local magnetic influence of the aircraft in which the compass is mounted. It is the angular difference between *mag-*

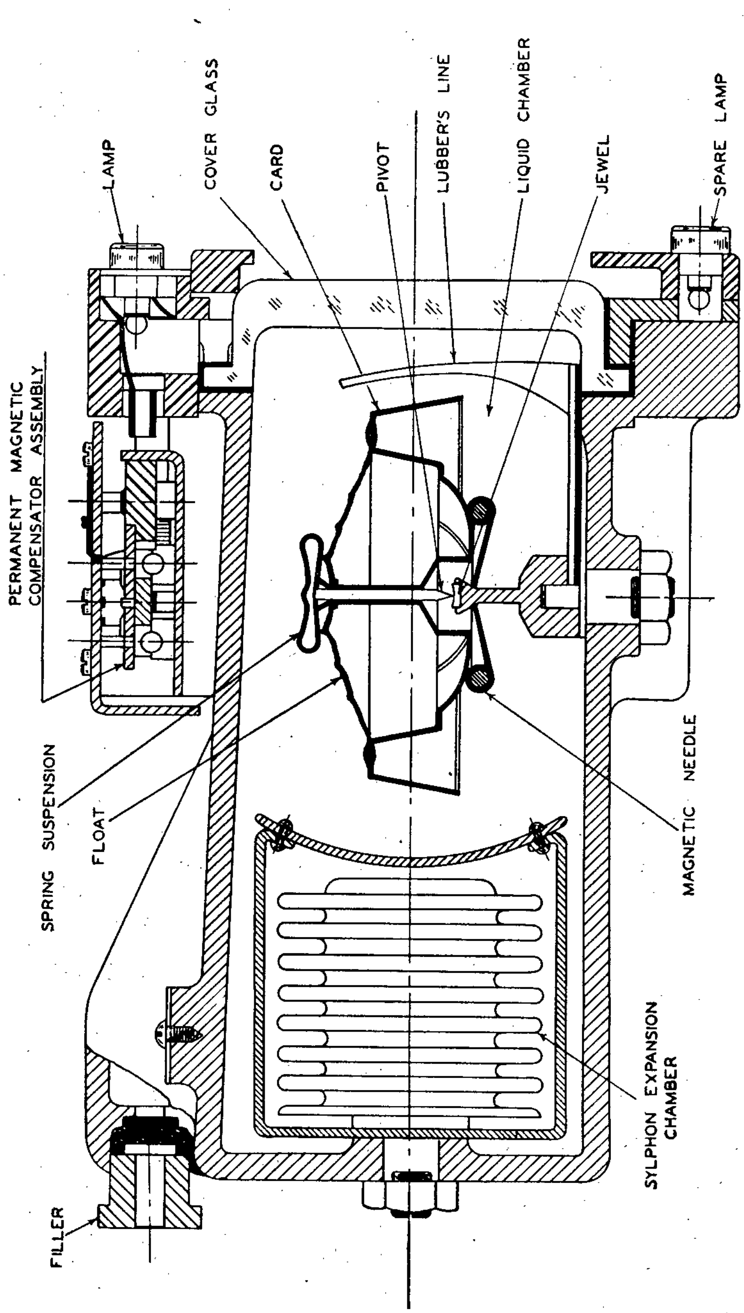


FIGURE 97.—Magnetic compass (cross section).

netic north and *compass* north. As in variation, it is termed "west" when the influence acting upon the needle draws it to the left, or west; and "east" when the needle is drawn to the right, or east.

f. The type B compass (fig. 96) for pilot's use indicates magnetic directions continuously and does not require a setting by the pilot to obtain the heading of the airplane. The heading of the airplane may be read by viewing the indications on the compass card in reference to the lubber's line through a glass window in front of the compass bowl.

g. All compasses installed on trainers should be compensated and the readings recorded at the end of each period of 100 flying hours. However, if at any time the compass is suspected of being in error or the trainer moved to a new location it should be checked and compensated. The process of compensating for errors in compasses after installation, that is, correcting within close limits the errors caused by magnetic influences and obtaining and recording the final deviations at the various points on the compass, is termed "swinging the compass." The compensation of compasses installed in aircraft or trainers cannot be expected to remain accurate for very long periods of time as it is known that under service conditions, the magnetism of the aircraft structure is constantly changing both in intensity and direction. The following instructions should be observed during the compensation of all magnetic aircraft compasses:

(1) Place E, W, compensating screws in the neutral position. (See fig. 96.) Some compasses are provided with two small white dots, one on the compensating screw and one on the instrument face ring, to be used as references in placing the compensating magnets in neutral position; however, the instruments not provided with such dots may be placed in their approximate neutral position merely by moving the screws until the screw driver slots are in the vertical position.

(2) Head trainer north by its own compass, and see that the square trainer base lines up with the fuselage. This should be checked carefully so that the base may be used as a "compass rose," to "swing ship" on the cardinal points. This alinement can be checked by sighting down past the side of the fuselage, seeing that it parallels the base. No other compass or north–south line is necessary.

(3) After the base is squared up with north as indicated by the trainer compass, turn the fuselage 90° to the right and *line the side of the fuselage up with the base*. Using the E–W compensator screw, adjust the compass to read exactly east.

(4) Next, have an assistant turn the trainer another 90° to the right and line it up again with the base. The compass should now read south but if there is any iron work in the building, or other magnetic interference, an error will be present. Using the N–S compensating screw, reduce the error by one-half its amount. This will divide the error between northerly and southerly headings.

(5) Next, turn the trainer to a westerly heading and line it up with the base. If the compass does not show exactly west, split the error as was done on the south heading.

h. Deviation card.—While making out the deviation card, the hood should be closed and the trainer running, but with the locking straps left on. The rudder must be in neutral to prevent the compass deflector (which simulates northerly turning error), from operating. It is essential to have an assistant stand outside the trainer and swing it to the desired headings and hold it steady while the compass settles down.

(1) Have the assistant head the trainer north and *line it up with the base.* Set the directional gyro to exactly zero. After the compass has stopped oscillating, note down its heading.

(2) Have assistant turn the trainer to a gyro heading of 30°, wait for the compass to settle and note down its heading.

(3) Turn to a gyro heading of 60° and repeat the process.

(4) Turn to an easterly heading and *line up with the base.* Note down compass heading as before, and check gyro for a heading of exactly 90°, resetting the gyro if necessary.

(5) Continue all the way around the compass in 30° intervals as above.

(6) If another assistant is available, time can be saved by attaching or checking the heading indicating pointers to the octagon, while the deviation card is being made. These pointers should be put on at 30° intervals, to show *magnetic* heading rather than *compass* heading, thus affording information to the instructor as to whether the student is correcting for deviation. The heading indicating pointers should be exactly 30° apart, by the directional gyro.

NOTE.—Some installations will permit the compass to be compensated to such an extent that no error will exist. While this is highly desirable in an airplane, it is almost never possible, so in order to simulate more accurately the actual conditions, never compensate the trainer's compass to such an extent that no error exists. Leave some error in the instrument so that it will be necessary for the trainer pilot to refer to the compass correction card when performing problems, just as he must do when performing similar problems in the air.

i. Maintenance.—The normal service consists of the replacement of defective lamps, tightening of screws to eliminate leakage of liquid, checking lighting system for defective electrical connections, compensation, and replacement of defective compasses. Compasses are removed and replaced by serviceable instruments if any of the following conditions exist:

(1) Clouded or discolored liquid which impairs visibility.

(2) Card markings are illegible due to discoloration, fading, or loss of luminous paint.

(3) Card does not rotate freely in a horizontal plane when trainer is in normal flying position. This may be checked by deflecting the card with a small permanent magnet.

(4) Bowl is cracked or mounting frame or lugs broken.

(5) Compass is not responsive or is erratic in action after proper efforts to compensate.

(6) Lubber's line is loose or misalined.

(7) Compass requires bench test, disassembly operations, additional liquid, or has any other major defects which might render it inoperative.

30. Vertical speed indicator.—*a.* This instrument (fig. 98), also known as the rate of climb indicator or climb and dive indicator, is designed to show on its calibrated face the *rate of gain or loss in altitude in hundreds of feet per minute.* Specific uses are to—

(1) Show ascent.

(2) Show descent.

(3) Accomplish banked turns without gain or loss of altitude.

(4) Establish predetermined constant and definite rates of descent when making instrument landings or instrument approaches.

b. The instrument (fig 99) consists essentially of an indicator unit with a thermos chamber, built as an integral part of the instrument case, a diaphragm, subjected to the air pressure existing in the thermos chamber through a diaphragm tube, and the necessary gear trains and linkages from the diaphragm to the indicator hand. The face of the instrument is provided with a zero adjustment screw that should be adjusted to bring the pointer to the zero position when the instrument is not being subjected to any change of pressure.

c. The vertical speed indicator is essentially a very sensitive manometer and operates from the differential between atmospheric pressure and the pressure of its thermos chamber, which is vented to the altitude tank through a small calibrated leak. The restriction of the leak at the exit of the chamber causes a definite pressure differential to be established between the outside and inside of the chamber when

the pressure in the tank is changing, as in ascending and descending maneuvers. The measure of this rate of change of pressure is indicated on the dial as a rate of change in altitude in feet per minute. A lag of from 7 to 10 seconds is built into all instruments of this type to prevent oversensitiveness, caused by bumps or very slight changes in altitude that occur due to turbulent atmospheric conditions which would be indicated by violent pointer oscillations. Some

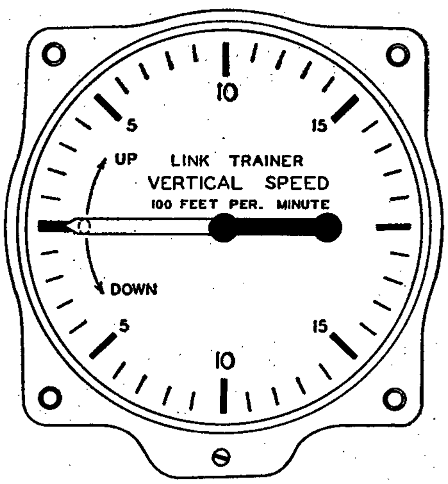


FIGURE 98.—Vertical speed indicator (face).

oscillation will be evident even with the lag factor present; however, they do not interfere with the practical application of the information the instrument furnishes.

d. The trainer instrument differs from the actual aircraft instrument only in that its gear train is so constructed to give pointer indications at the ratio of 2 to 1, or in other words, to show two units of rate of change in altitude for every one unit of actual change. This is necessary so that the instrument will be synchronized in its indications with the altimeter used in the trainer, which is also a 2 to 1 instrument.

e. This instrument is one of the remote indicating Telegon instrument on late model trainers, and is provided with a zero adjusting knob on the rear of the transmitter case, in place of the conventional screw, or knob, on the instrument face.

31. Altimeter.—*a.* The altimeter (fig. 100) is used in aircraft to measure the elevation of the aircraft above some point on the ground, regardless of its elevation above sea level, or to measure the elevation of the aircraft above sea level. The trainer instrument serves es-

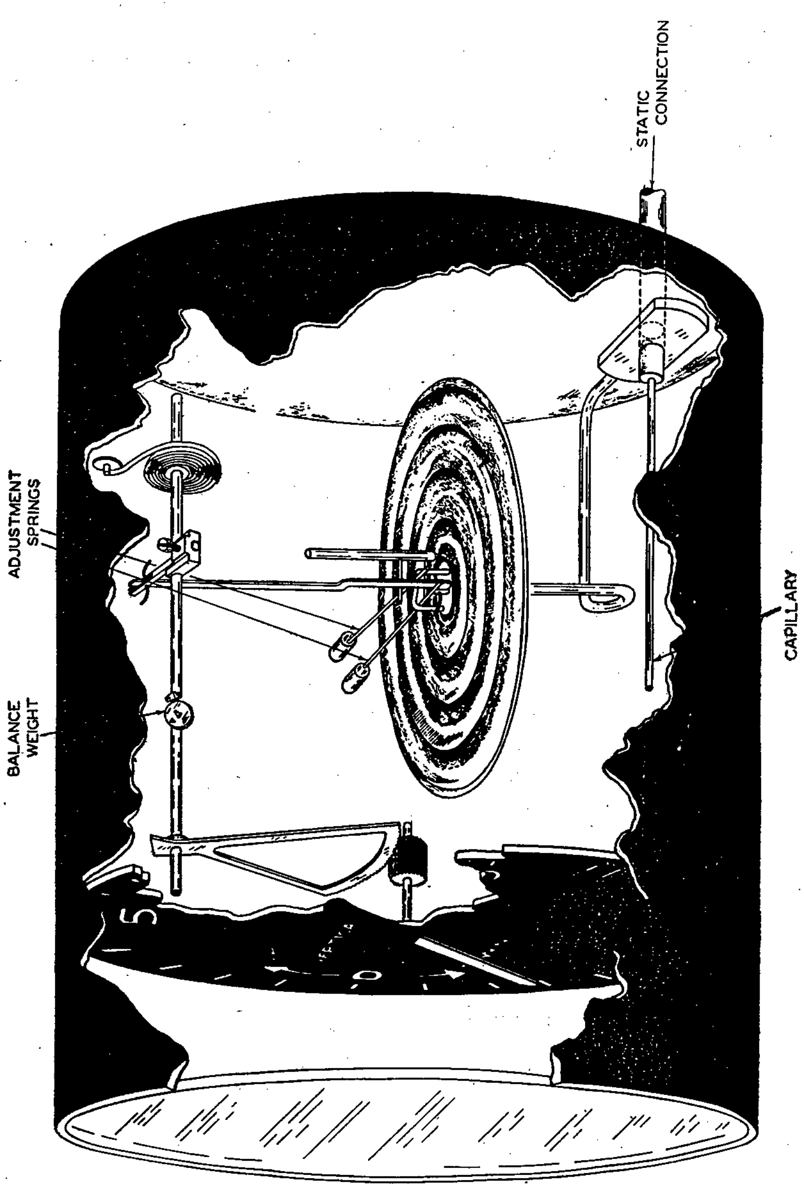


FIGURE 99.—Vertical speed indicator (cutaway).

sentially the same purpose in measuring the simulated altitude existing in the altitude system.

b. Specific uses are as follows:

(1) To determine accurately the vertical distance between the aircraft and objectives on the ground when performing tactical missions.

(2) To indicate the elevation of the airplane above the runway for coordination with instrument indications when making instrument landing or approaches.

(3) To indicate at all times the elevation of the airplane above

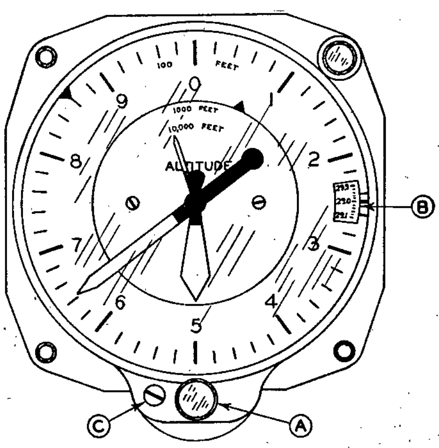


FIGURE 100.—Altimeter (face).

sea level, so that it may be compared with strip maps or known information as to the height of obstructions on the ground so they may be safely cleared.

(4) To furnish information as to the aircraft's height so that meteorological data, such as wind velocities and directions at various elevations, elevation of cloud and storm formations, may be considered, avoided, or taken advantage of.

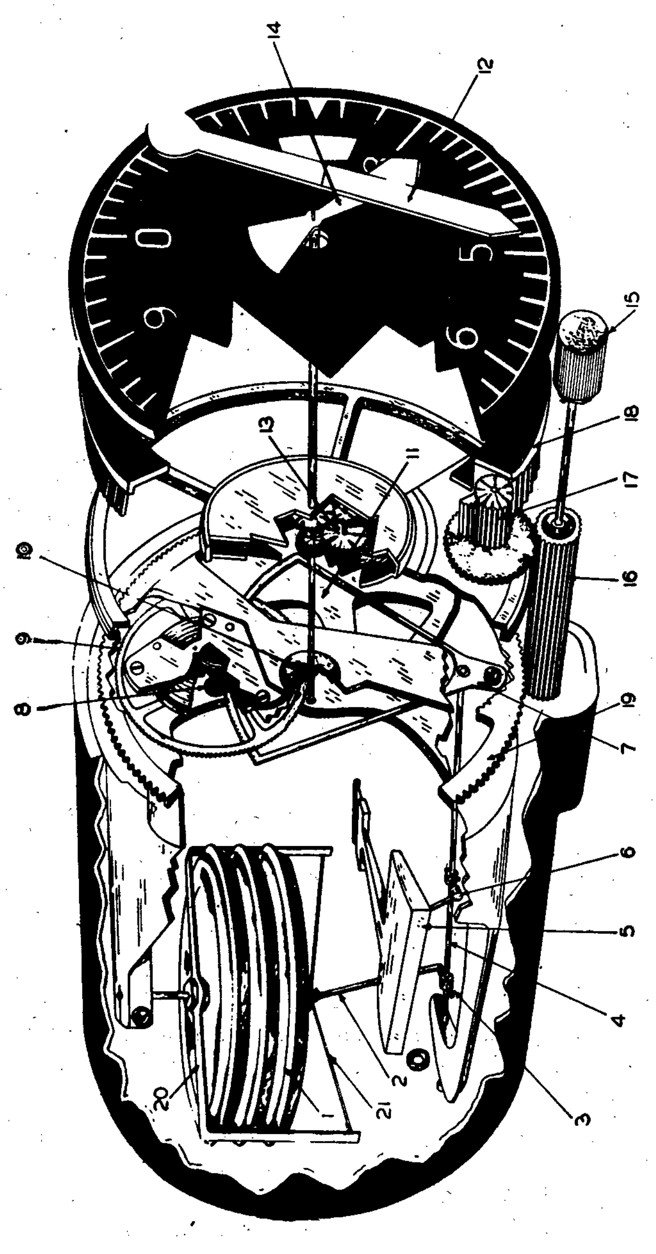
(5) To provide information so airway traffic regulations may be observed and correctly followed.

(6) To furnish data for changing blade settings of propellers, operation of engine superchargers, and oxygen equipment.

c. All altimeters (fig. 101) used in military aircraft are of the sensitive type utilizing an aneroid mechanism, a temperature compensator bi-bar, to compensate for the expansion and contraction of metals used in the linkages due to changes in temperatures at different altitudes, and the necessary linkage and gear trains to actuate the indicating hands.

d. Standard models of altimeters for tactical operation have a calibrated range of from 1,000 feet below sea level (−1,000 feet) to 35,000 feet above sea level (+35,000 feet). By use of a multiple-pointer system, the instrument can be read accurately to at least one-half the smallest unit graduation on the scale. The later types of altimeters have one altitude scale, one barometric scale with an index marker, two reference markers, and three pointers. The altitude scale, having major divisions of 0 to 10, is fixed and the pointers, reference markers, and barometric scale rotate and indicate with reference to it. A setting knob located at the bottom front of the instrument case drives two pinions in opposite directions. One of these pinions rotates the barometric scale and reference markers and the other pinion rotates the aneroid mechanism assembly of which the pointers are a part. The three pointers or indicating hands are concentrically arranged and indicate on the one common dial. The long pointer is referred to as the "minute hand", the intermediate pointer as the "hour hand", and the small pointer as the "second hand". The minute hand makes one revolution for a change of 1,000 feet, the hour hand makes one revolution for a change of 10,000 feet, and the second hand would indicate 100,000 feet for one revolution if it were not restrained. To cover the full range of the instrument, the minute hand makes a total of 36 revolutions, the hour hand 3.6, and the second hand 0.36. The position of the reference markers are read on the same dial as the pointers. The outer one which rotates on the periphery of the dial makes one revolution for 1,000 feet and the inner one makes one revolution for 10,000 feet. The standard range for the barometric scale is 28.1 to 31.0 inches Hg with unit graduations of 0.02 inches of Hg. When the limit of the range of the barometric scale is reached at either extreme, a shutter blanks out the indication of the barometric dial and the barometric pressure is read from the position of the reference markers by computation. By introducing a limited range barometric scale, the actual unlimited possibilities of setting barometric pressure by means of the reference markers is not in any way affected. The entire mechanism is enclosed in a two-piece bakelite case which is provided with a vent in the rear case wall for connection to the altitude system of the trainer.

e. The altimeter being an absolute pressure-indicating instrument is operated by the changes in the altitude system's pressure. The only difference between the actual aircraft instrument and the trainer instrument is the fact that the gear is ratio of 2 to 1 over the standard instrument. For each change, in amount, of one unit of pressure a two-unit indication is given. It is the third of the remote indicating



INDICATING SYSTEM

1. SENSITIVE EVACUATED METAL DIAPHRAGM
2. DIAPHRAGM LINK
3. DIAPHRAGM CALIBRATING ARM
4. ROCKING SHAFT
5. BALANCE
6. BALANCED CONNECTING LINK AND ARM
7. SECTOR GEAR
8. INTERMEDIATE PINION GEAR & HAIR SPRING ASSEMBLY
9. INTERMEDIATE WHEEL
10. HAND STAFF PINION
11. HAND STAFF
12. LARGE POINTER
13. REDUCING GEAR TRAIN FOR SMALL HAND 10 TO 1
14. SMALL HAND

BAROMETRIC SETTING SYSTEM

15. BAROMETRIC SETTING KNOB
16. ADJUSTMENT KNOB PINION
17. IDLER GEAR & PINION
18. BAROMETRIC SETTING SCALE
19. MECHANISM BODY GEAR

FULL RANGE TEMPERATURE COMPENSATING MECHANISM

20. THERMO-METAL COMPENSATOR BRACKET
21. PUSH RODS

FIGURE 101.—Altimeter, cutaway.

instruments of the Telegon system of late model trainers, consisting of the instrument proper (transmitter) and the two remote indicating assemblies, all three of which must be synchronized. With the oscillator and vibrator motors turned on and the vacuum turbine turned off so that no pressure differential exists in the altitude system, the transmitter will remain in the base (no indication) position. However, the two indicating assemblies may give an indication of altitude, in which case they must be changed to give a −500 feet altitude indication. In a second instance, the two indicators may be out of synchronization with each other; if the latter is true proceed as directed in *f* below.

f. Synchronizing altimeters.—To synchronize the altimeters, turn on the oscillator. Each instrument is furnished with a setting knob (A), by which the barometric scale is adjusted. Set these scales to exactly agree. The large pointers of the two instruments should now agree even though the small pointers are out of synchronization. If the large hands do not exactly agree when the barometric scales (B) are together, proceed as follows: Set the large hands to exactly agree. Just to the left of the adjusting knob, is a countersunk screw (C); loosen this screw until it can be moved slightly sideways. By pulling gently out on the knob (A) (like setting a watch) the barometric scale can be moved without disturbing the hands. Set the scales to exactly agree with each other; then replace knob and screw.

g. To synchronize the small hands.—If one of the altimeters is too low (1,500 or more feet below zero), disconnect the cable from the back of the other altimeter. ***Caution:*** The oscillator must be *off* when connecting or disconnecting altimeters. Turn on the oscillator and the trainer, and climb until the low altimeter is brought to 500 feet below zero. Shut off the oscillator and reconnect the other altimeter. Shut off the trainer and allow about 5 minutes for vacuum to be lost before starting normal operation. If one of the altimeters is too high when at rest, disconnect the low one. Leave the oscillator off and climb the trainer to an altitude greater than that shown by the high altimeter. (This must be estimated as the indicators will not be working.) Turn on the oscillator and as soon as the instruments "come alive" turn off the trainer. Watch the altimeter that is being corrected and when it reaches approximately 500 feet below zero, turn off the oscillator and connect the other instrument. Allow about 5 minutes for all vacuum to be lost before starting normal operation. If both altimeters are a thousand feet or more too high or too low when at rest, proceed as in correcting only one but leave both connected. If both are too high or too low and one higher than the other, leave both connected and when one reaches 500 feet below

zero shut off the oscillator and disconnect this instrument. Then proceed as just outlined to correct the remaining instrument.

32. **Directional gyro.**—*a.* The proper Army Air Forces nomenclature for this instrument is "indicator assembly, turn"; however, to avoid any confusion between it and the turn and bank indicator it is generally referred to as the directional gyro (fig. 102).

b. The purpose of this instrument is to provide a fixed reference for maintaining flight direction. Specific uses are as follows:

(1) To supplement the magnetic compass.

(2) To indicate magnitude or amount of turn.

(3) To aid in compensation and correction in swinging compasses.

(4) To maintain alinement when making instrument landings and low approaches.

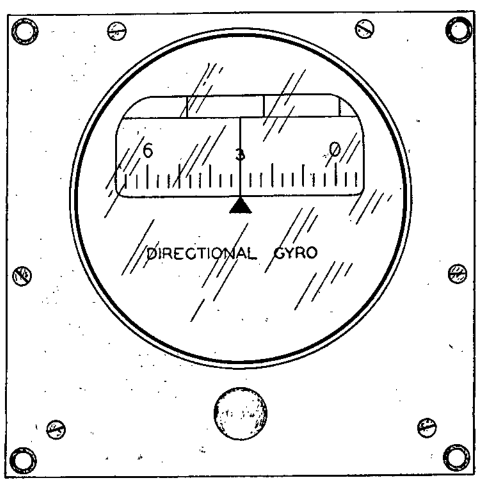


FIGURE 102.—Directional gyro (face).

c. The Standard Army Air Forces type A instrument may be used to replace the instrument supplied with the trainer in event that it exceeds the tolerance limits specified herein; however, the type A instrument differs from the standard trainer instrument in that an inclinometer is incorporated in the former and for the reasons outlined previously will not give correct indications on the trainer, so if a type A instrument is mounted in the trainer the inclinometer portion must be covered so as not to cause confusion between its indications and the indications of the inclinometer on the turn and bank indicator.

d. The turn indicator mechanism shown in figures 103 and 104 is basically a horizontal, axis-free gyro provided with an azimuth card

and setting device. The rotor is universally mounted; that is, it is supported in a gimbal ring which is free to turn about an axis on bearings in the vertical ring. The vertical ring is free to turn about the vertical axis. The circular card which is attached to the vertical ring is observed by the pilot through the rectangular opening in the front of the instrument case. The entire assembly is supported and carried on bearings of which the pivots are mounted in the top and bottom plates of the instrument case. The caging knob protrudes through the front of the instrument case. It is used to set the gyro and card assembly on the desired heading and to reset it at periodic intervals for course keeping when flying by compass. By pushing the caging knob "in," it engages the synchronizer lever plunger which normally rests in the cone-shaped interior of the pinion and raises the lever pins which slide in the groove of the synchronizer ring. This lifts the synchronizer ring, pushing up the spring plunger and raising the caging arm so that it makes contact with the bottom of the gimbal ring and holds the gyro horizontal as the card is turned to the desired heading. Pulling the caging knob "out" releases the caging mechanism and leaves the gyro horizontal and free.

e. The air stream which spins the rotor enters through a filtered opening around the bearing pivot on the bottom plate and is divided into two parallel jets; the air from each jet is directed through nozzles onto the buckets in the rim of the rotor at points equidistant from the center. The pressure exerted by the air on the rotor circumference serves to keep it upright. If the rotor tilts, the air from the jet on one side strikes against the rim instead of against the buckets while air from the other jet strikes the side of the buckets causing the rotor to return to its upright position.

f. Operation.—*a.* The object of the turn indicator is to establish a fixed reference for maintaining flight direction. The gyroscope, which is simply a spinning wheel mounted so its axle can be pointed in any direction, affords the best way of obtaining this reference without excessive size and weight. Relative movement of the airplane in azimuth is shown on a circular card graduated in degrees.

g. The turn indicator is operated by vacuum at 4 to 5 inches Hg, supplied by means of a direct line to the air transfer manifold. The rotor spinning about a horizontal axis at approximately 10,000 rpm is so mounted as to be free about the three directional axes. The card, graduated in degrees, is attached to the vertical ring in which the rotor and its gimbal ring is mounted. The vertical ring and card are free to turn about the vertical axis and a rectangular opening in the front of the instrument case permits a view of an ample sector

of the card. The gyro axle is horizontal in normal operation. When spinning, the gyro obeys a fundamental gyroscopic principle, rigidity. Thus, the rotor and gimbal ring and the card which is attached to the vertical ring remain fixed, and the airplane moves around them.

h. Unlike a compass, the turn indicator has no directive force to

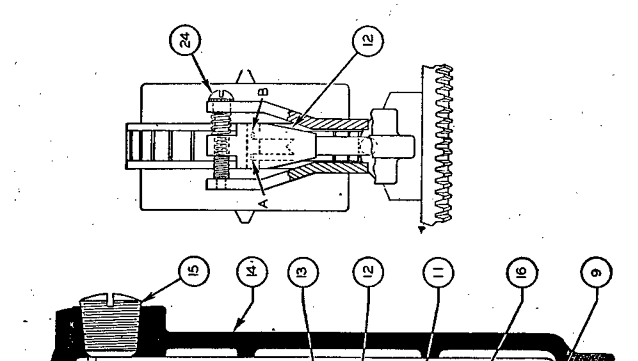


FIGURE 103.—Directional gyro (side view).

return it to a fixed heading. It must be checked occasionally, and if necessary, reset by means of the caging knob underneath the dial. Pushing this knob in (push in with slight clockwise twist to avoid injuring gears) engages the synchronizer pinion with the synchronizer

gear. By turning the knob, the card can be set by means of the reference line in the window to correspond with the compass heading or it can be set on zero when measuring amount of turn from an established heading. After setting the card, pull out on the knob (straight out) and the instrument is in operation thereafter, unless it is either upset or recaged. Any degree of bank or pitch exceeding 55° will upset the gyro and in all probability the card will start to spin, consequently the instrument is useless until the airplane is again leveled and the gyro caged and reset. The gyro in the turn indicator should always be caged if acrobatics are to be performed. The sensi-

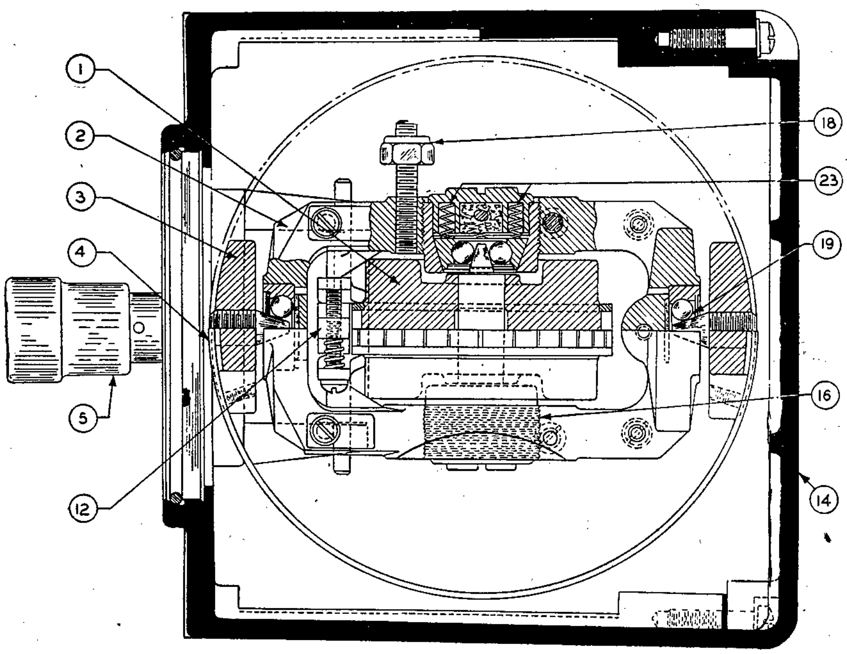


FIGURE 104.—Directional gyro (top view).

tive pivots and bearings are less subject to damage and the over-all life of the mechanism before overhaul will be increased. However, since pitching or banking of the trainer is limited to approximately 30° maximum, the normal trainer instrument will never upset.

i. Directional control is accomplished with the directional gyro which is read in the same manner as a vertical card magnetic compass. More accurate control is possible due to the fact that the directional gyro does not swing or oscillate but remains fixed and therefore provides as positive a reference for steering, such as objects along a clear natural horizon. The directional gyro must be originally set to the

magnetic compass and reset at intervals from 15 to 20 minutes to take up for creep of the gyro. The average creep on cardinal headings should not exceed 3° in 15 minutes and the creep on any single heading should not exceed 5° in 15 minutes. Care should be taken when setting or resetting the directional gyro, especially in rough air, to be certain that a correct compass reading is obtained. It must be remembered that even when flying straight in rough air, the magnetic compass will swing to a certain extent. When the magnetic card appears to be still, it is actually at the end of a swing and therefore farther from true magnetic azimuth. If the directional gyro is set to the magnetic compass at one end of a swing and observed a short time later in connection with the compass when the compass is at the opposite end of a swing, it will seem as though there had been an excessive creep of the gyro. To avoid this trouble, the airplane or trainer should be held as straight as possible for about a minute by a directional gyro setting, approximately the same as the compass reading, during which time the compass may be observed to determine its average reading during swings, and the directional gyro then properly set. When uncaging the gyro after setting, the caging knob should be pulled straight out.

j. Maintenance.—Improper operation is usually caused by excessive vibration or improper supply of vacuum. If the turn indicator does not function properly, the vibration of the instrument board and the vacuum supply is checked before removing the instrument from the trainer. If the trouble is found to be due to conditions within the instrument, it should then be removed and replaced with one that is serviceable. The shafts, pivots, and ball bearings of the instrument are lubricated before assembly in the case at the factory or Army Air Forces repair depots and no further lubrication will be accomplished by service activities with the exception that if the caging knob is hard to pull out or push in and turns excessively hard, add a few drops of instrument oil to the surface of the shaft that passes through the front plate of the instrument case. The frequency of cleaning the air intake filter will depend upon the service conditions. To clean the intake filter on the bottom of the case, the snap ring and screen are lifted out with a scribe. It is not necessary to remove any screws. The filter is cleaned with carbon tetrachloride, dried, and replaced. When cleaning a filter, it should be thoroughly examined and if found defective replaced with a new one.

33. Radio compass indicator.—This instrument is nothing more than a voltmeter with zero in the center, that indicates the fact that voltage is applied, and the direction of the current's flow by means of

a moving coil (fig. 105), to which the indicator hand is attached, in a permanent magnet field. Total resistance is 200 ohms; sensitivity is 1 volt from zero center. An external mechanical zero adjustment screw is provided on the face, through the glass, for zeroing the indicator hand when no voltage is applied to the terminals on the back of the instrument.

34. Gas gage.—*a.* The fuel gage (fig. 106) is a clockwork with a single pointer and dial graduated in gallons. After being wound up to its full capacity of 50 gallons, it requires approximately 1 hour to run down. When the pointer has run down to the zero mark, a switch is automatically opened. This switch is wired in series with the trainer

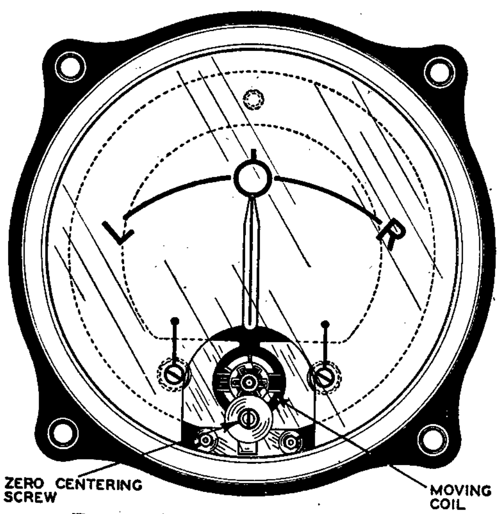


FIGURE 105.—Radio compass indicator.

main switch (ignition switch) so that when the gage reads "empty" and this switch is opened, the trainer is automatically turned off. A toggle switch is provided, located just above the ignition switch, which is wired so as to bridge the switch in the fuel gage. When this switch is closed, the switch in the fuel gage has no effect on the operation of the trainer.

b. A special key is provided with which the fuel gage is wound up like a clock. This key is ordinarily retained by the instructor. The mechanism consists of a main spring, a short train of gears, an escapement similar to that in a clock, plus the switch. The unit can be wound to any value desired by the instructor according to the particular problem about to be run.

35. Clock.—*a.* Trainers are not ordinarily delivered with clocks installed, so it is necessary in most instances to obtain clocks from the

local Army Air Forces supply and mount them on the instrument panel. Any one of several different Army Air Forces standard clocks such as A-6, A-7, A-8, or A-9 may be installed; however, the space provided for the clock installation on the instrument panel is, for most types, much too large, necessitating the use of a locally manufactured adapter for all types, with the exception of the A-8 model.

b. All models in use at the present time with the exception of the A-8 are of the conventional 8-day full sweep second hand type and require no special instructions as to their use or care; however, the A-8 is quite complicated and requires explicit directions for its proper use to avoid possible damage to it.

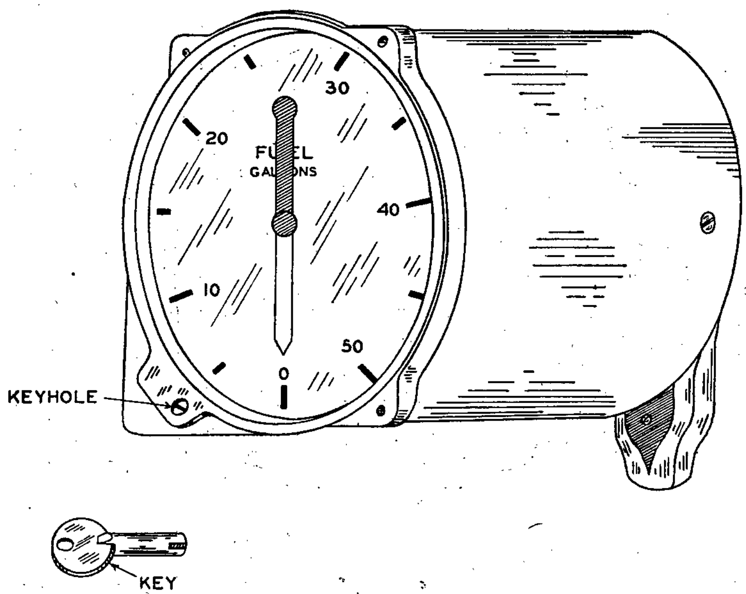


FIGURE 106.—Fuel gage.

c. Figure 107 illustrates the A-8 which in addition to the standard clock face and full sweep second hand has features which provide for split second timing by provisions for stopping and starting the full sweep second hand and an elapsed time dial with provisions for stopping, resetting, starting, and for taking time out.

d. Operation instructions are furnished only for A-8 clocks as all other types are conventional clocks. All controls are forward (in front) around the bezel, there being three knobs, as follows:

(1) Split-second timing is operated by pushing right-hand button to start, stop, and return the split-second hand to zero. The smaller inner dial at the bottom records minutes traversed by the split-second

hand. ***Caution:*** *The stop second hand must not be run continuously.*

(2) For elapsed time use the red portion of the left-hand button to start, stop, and return the elapsed time hands of the upper small inner dial to zero.

(3) The third button immediately below the 6 o'clock location permits the stopping of the elapsed time hands (by turning to the right) which allows for taking time out for refueling, repairs, etc., and by again turning the small button to the left, the elapsed time is resumed, thus making it possible to keep an exact record of flying time, or any definite period. When the indicator, located within the upper small inner dial is red, the elapsed time hands are functioning. When the indicator is red and white, the elapsed time

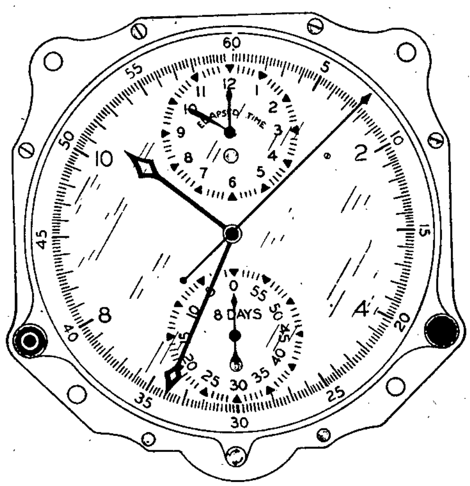


FIGURE 107.—A-8 clock (face).

hands have not been stopped. When the indicator is white, the elapsed time hands are not in motion (neutral).

36. Instrument panel.—*a.* The trainer instrument panel is basically the same on all trainer models as to its general lay-out and the instrument switches and various controls included on it. The instrument lay-out is designed to conform with the general instrument board composition of all airplanes; however, due to space limitations, and various installation troubles, the same pattern cannot be following for all types of airplanes.

b. The trainer lay-out is designed to present a minimum of eye-strain on the pilot; to place the various instruments in the position where they can be referred to for their readings; and, for comparison with the readings of their associated instruments, with a mini-

mum amount of eyestrain and parallax. For example, the air speed indicator, turn and bank indicator, and vertical speed indicator, all instruments whose indications are very closely associated for proper

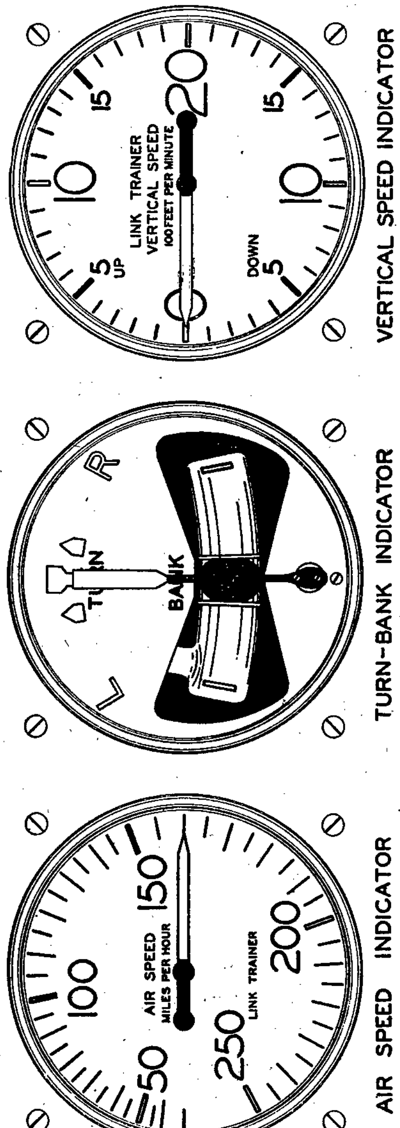


FIGURE 108.—Instrument board composition, three instruments.

control of the airplane or trainer, are mounted in the order named, in the center of the panel, so as to present a triangle of indicator pointers for quick easy reference when the airplane is in straight and

level cruising position. (See fig. 108.) Figures 109, 110, 111, and 112 are drawings of the instrument panels currently in use on C-2, C-5, C-4, and C-3 trainers.

37. Compass deflector.—*a.* The compass in the trainer is a standard aircraft instrument, but due to lack of centrifugal force during turns, no northerly turning errors occur. It is, therefore, necessary to introduce a device which will cause the compass to simulate this turning error. A small electromagnet is mounted directly under the compass. Current is supplied through a set of contacts mounted on the rudder valve. These contacts consist of two fixed contact plates attached to the lower, fixed half of the valve, and a third contact attached to the top, movable part of the valve. When a left turn is started, the moving contact closes the circuit through one of the fixed contact plates and current flows through the coil of the magnet in one direction; when a right turn is started, the other fixed plate carries current through the coil in the other direction. The direction of current flow determines the direction of compass swing.

b. Power is obtained from the 12-volt a-c transformer located in the fuselage control box on C-5 and C-3 trainers, and mounted on the back of the instrument panel on previous models. This current is rectified by a dry disk rectifier to provide direct current for the electromagnet. This current passes through a variable resistor so that the current and amount of compass deflection may be set to the desired value. The resistor is mounted on the compass deflector assembly mount, under the compass on models previous to C-5 and C-3's, and in the fuselage control box on the later models.

c. If a slow turn is started from a northerly heading, the compass should start to swing when the turn and bank indicator shows one-half the deflection of a standard rate (3° per second) turn. ***Caution:*** The turn and bank indicator must have been running long enough to attain normal operating speed. If the needle is too far out when the compass starts to swing, the contact plates on the bottom half of the rudder valve (fig. 113) must be moved slightly nearer each other. Adjust the right-hand plate for left turns, and the left-hand plate for right turns. If the compass swings with too little movement of the turn and bank indicator pointer, the plates should be moved apart slightly. Both contact plates and the moving contact must be kept clean.

d. The amount of effect on the compass is determined by adjustment of the sliding contact on the resistor located in the fuselage control box. To check the amount of deflection, head the trainer north and turn on the main switch. Have someone hold the trainer

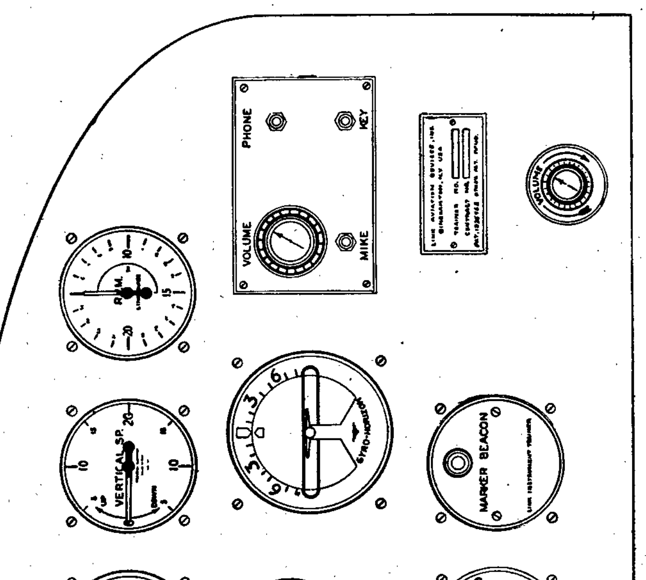
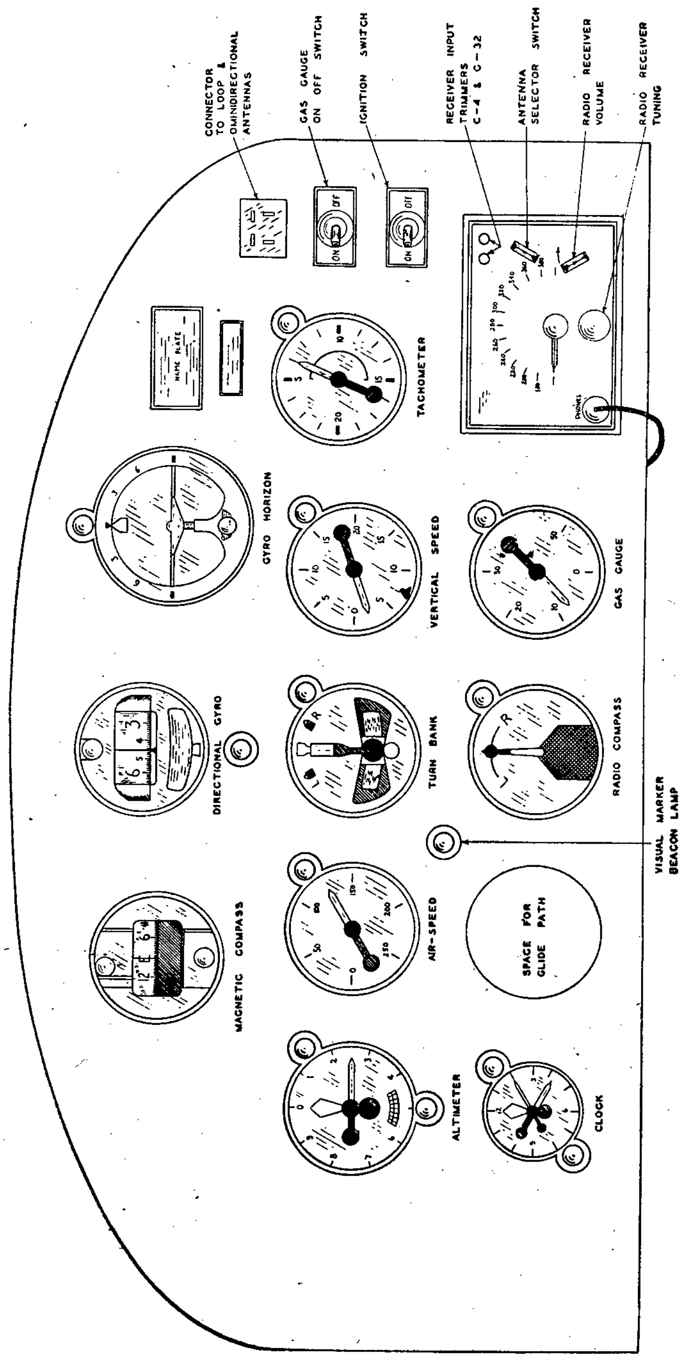
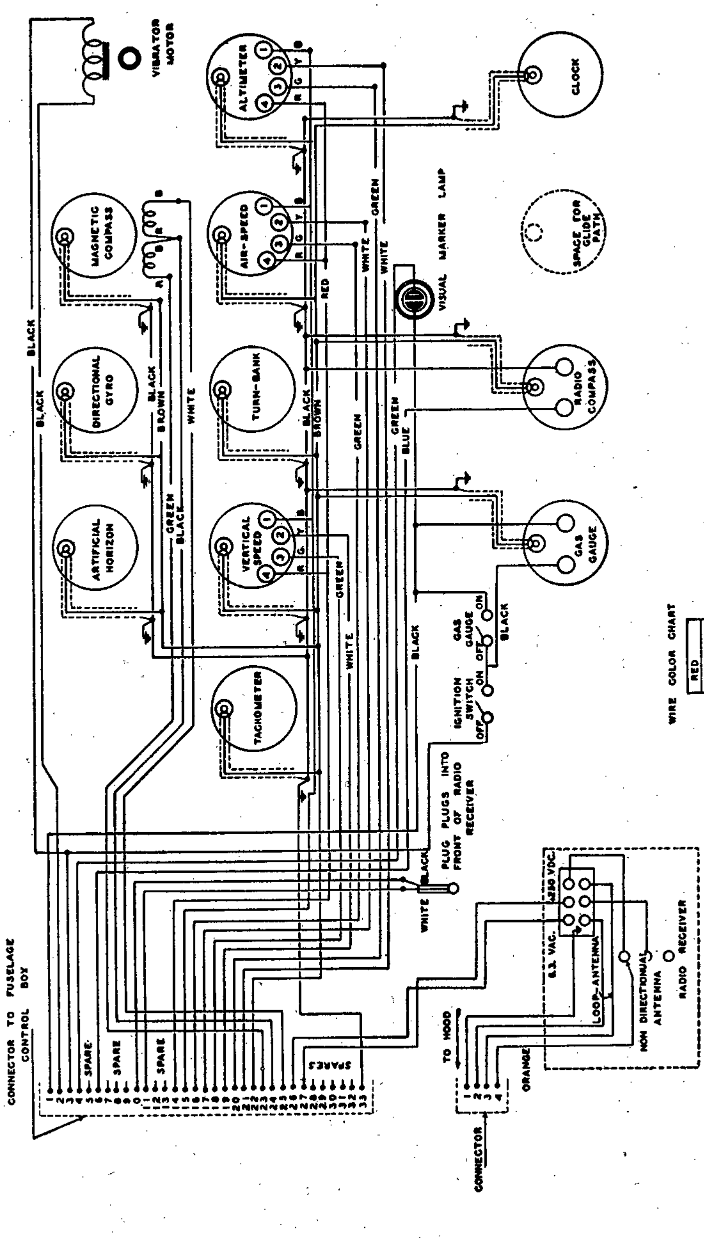


FIGURE 109.—C-2 instrument panel.


CONNECTOR TO LOOP & OMNIDIRECTIONAL ANTENNAS
GAS GAUGE ON OFF SWITCH
IGNITION SWITCH
RECEIVER INPUT TRIMMERS C-4 & C-32
ANTENNA SELECTOR SWITCH
RADIO RECEIVER VOLUME
RADIO RECEIVER TUNING
NAME PLATE
TACHOMETER
PHONES
GYRO HORIZON
VERTICAL SPEED
GAS GAUGE
DIRECTIONAL GYRO
TURN BANK
RADIO COMPASS
VISUAL MARKER BEACON LAMP
MAGNETIC COMPASS
AIR-SPEED
SPACE FOR GLIDE PATH
ALTIMETER
CLOCK

① Schematic.



② Wiring diagram.

FIGURE 110.—C-5 instrument panel.

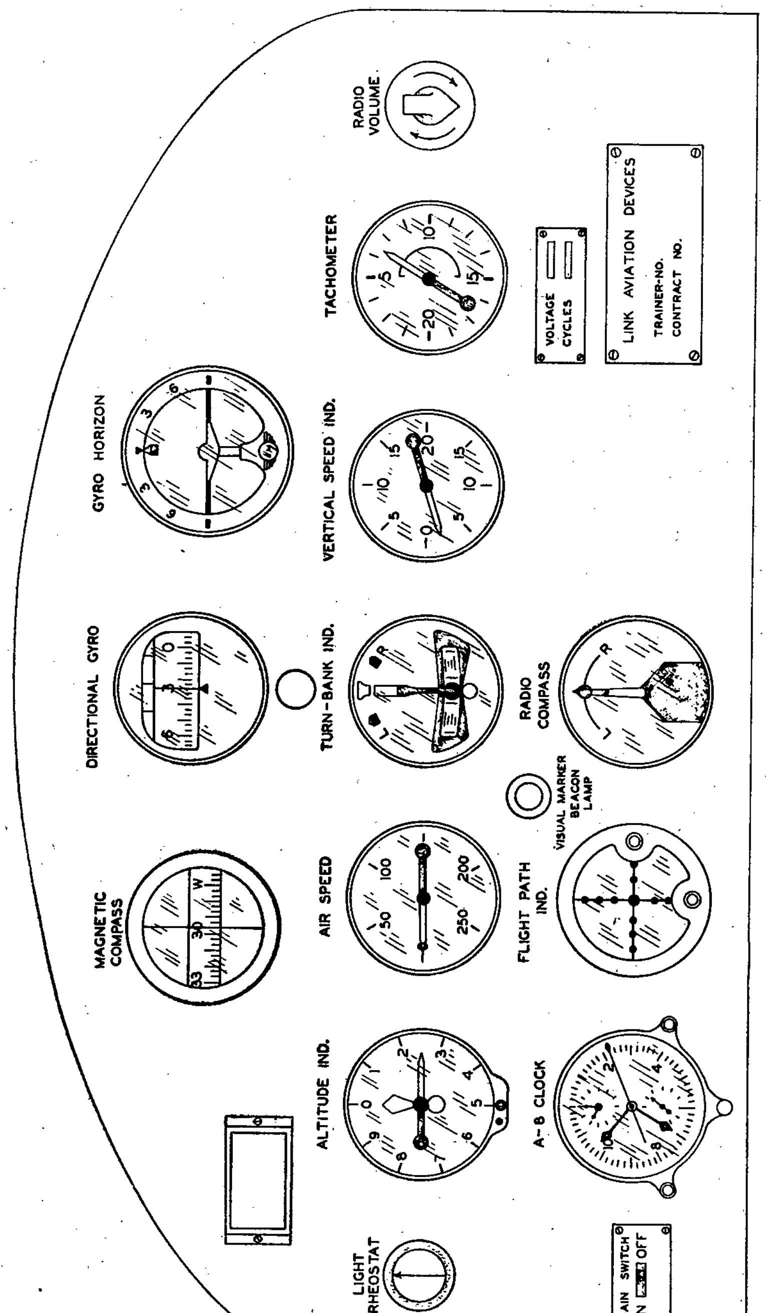


FIGURE 111.—C-4 instrument panel.

from turning and apply enough rudder to deflect the compass. It should deflect approximately 30°. When the left rudder is applied, the compass should swing to a heading of about 30°; when right rudder is applied, it should swing to about 330°. (In the Southern Hemisphere, the swing should be reversed. To accomplish this, simply reverse the wires leading to the two plates on the rudder valve.)

38. Vibrator motors.—*a.* A vibrator motor is used on the instrument panel. The sole purpose of this motor is to provide vibration to counteract friction in the instruments. Trainers having remote indicating instruments have two other vibrator motors; one in the desk instrument cabinet, and the other on the transmitter panel in the rear of the fuselage.

b. These vibrator motors operate on 110-volts, and each motor has two small, brass, eccentric flywheels mounted on its armature shaft. The position of vibrator weights has a direct effect on the instrument actuation. The desired amount of vibration is such that the instruments, when deflected, will return to zero smoothly and continuously without occasional interruption. This indication of instruments may be obtained by starting it with a minimum amount of vibration and gradually working up to the desired effect. Since instruments cannot be built entirely free of friction, they require a certain amount of vibration to obtain smooth operation. If an instrument lags excessively and then moves unsteadily, it indicates insufficient vibration. If instruments become abnormally sluggish, it is sometimes necessary to increase the amount of vibration by further unbalancing the flywheel. ***Caution:*** *Too much vibration has been known to cause extremely erratic instrument indications.* If this condition is suspected, stop the vibrator by grasping the small flywheel and note the effect, if any, on the instrument. Vibration is maximum when the two halves of the flywheel are in line with each other, as in position "A," figure 114; minimum when they are opposite to each other as in position "B"; and in position "C" half or normal vibration is achieved. Excessive end play of the flywheel shaft will also cause erratic instrument indications. The inner half of the flywheel should be set on the shaft so that the end play in the shaft is $\frac{7}{1000}$ of an inch.

c. The vibrator motors must be cleaned and lubricated on every maintenance, or inspection period, with the exception of the daily.

39. Telegon system.—*a.* The Kollsman Telegon system of remote indication is used on the instrument trainer in order to have identical instrument readings on duplicate sets of instruments, one

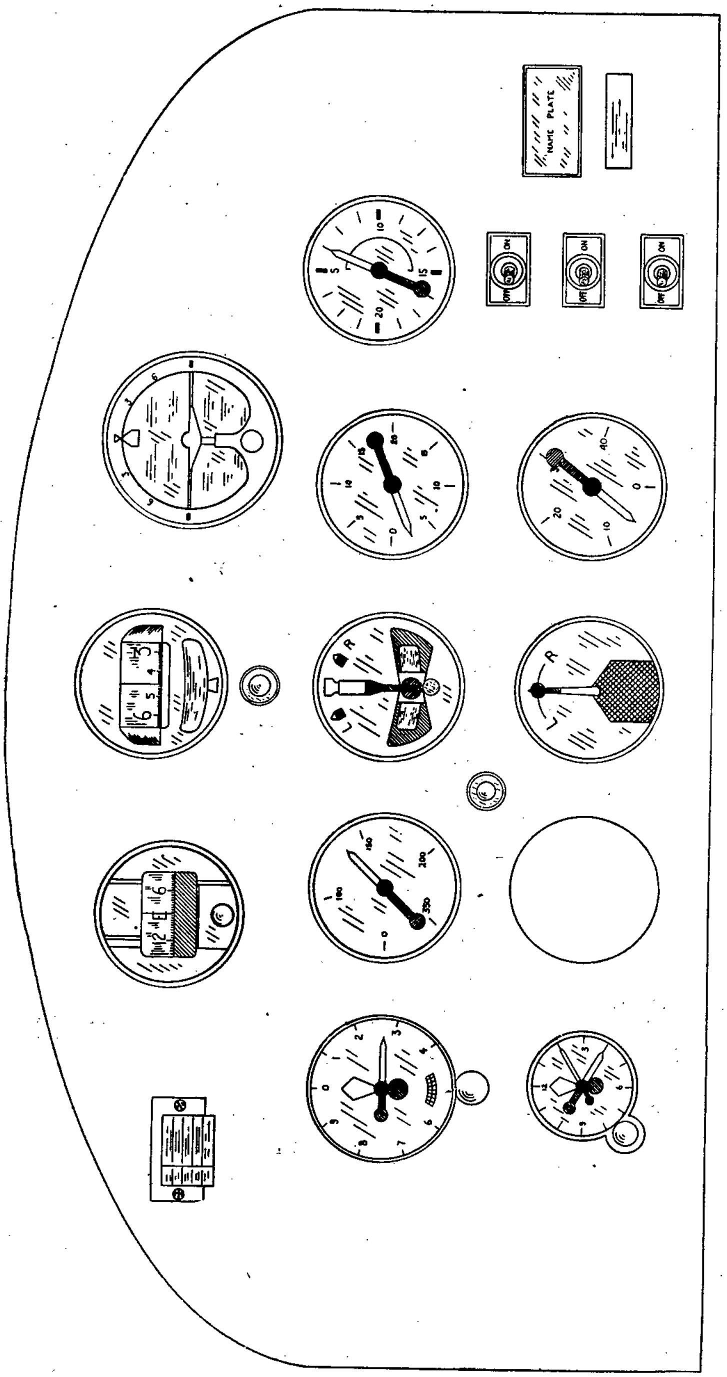


FIGURE 112.—C-3 instrument panel.

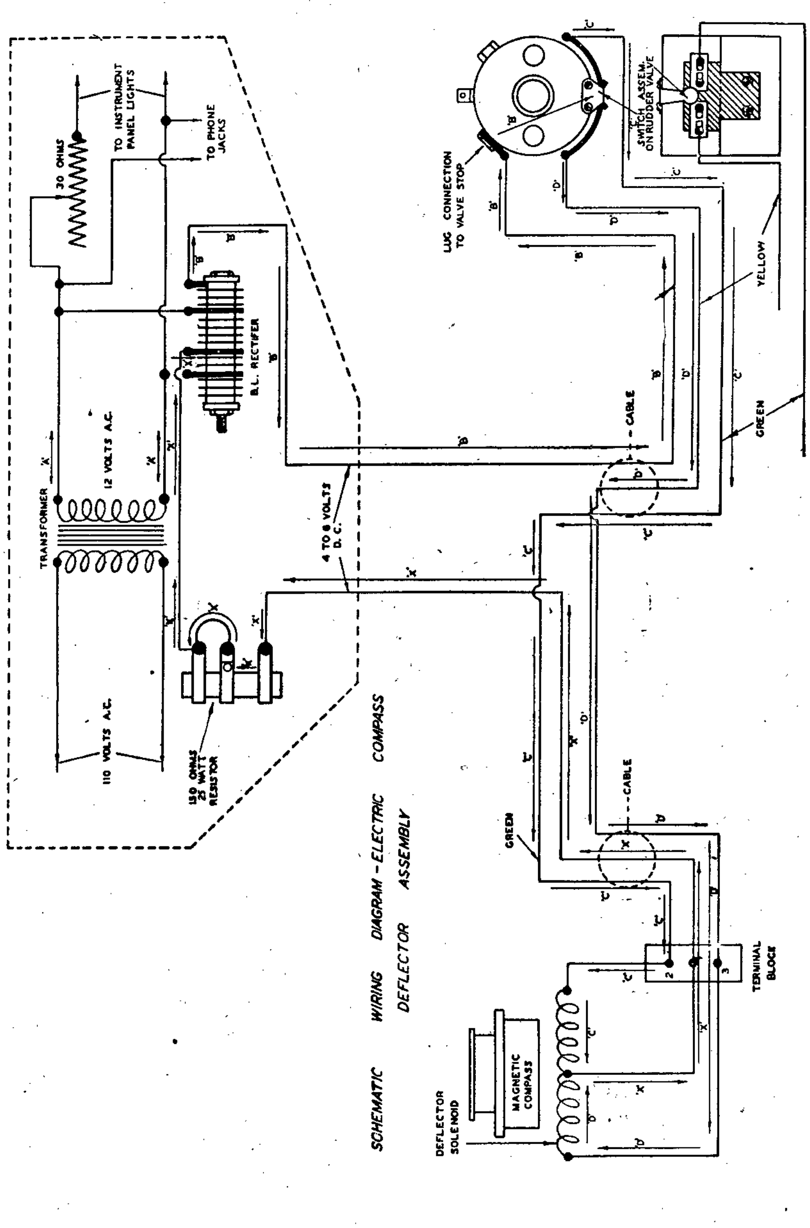


FIGURE 113.—Compass deflector circuit, schematic.

of which is located on the instructor's desk and the other on the instrument board of the trainer fuselage.

b. The remote indicating system (fig. 115) consists of a single transmitting unit, located at the source of measurement, and two indicating units, one of which is mounted on the instrument board of the trainer's fuselage, and the other at the instructor's desk. The transmitter is a Kollsman Telegon unit which is actuated by an instrument mechanism similar to standard instruments. The indicator consists of a Telegon unit which is structurally identical with the transmitter unit and which carries the instrument dial and hand. The complete Telegon system consists of these three remote indicating systems (air speed, vertical speed and altimeter), an oscillator, and the necessary cords and plugs.

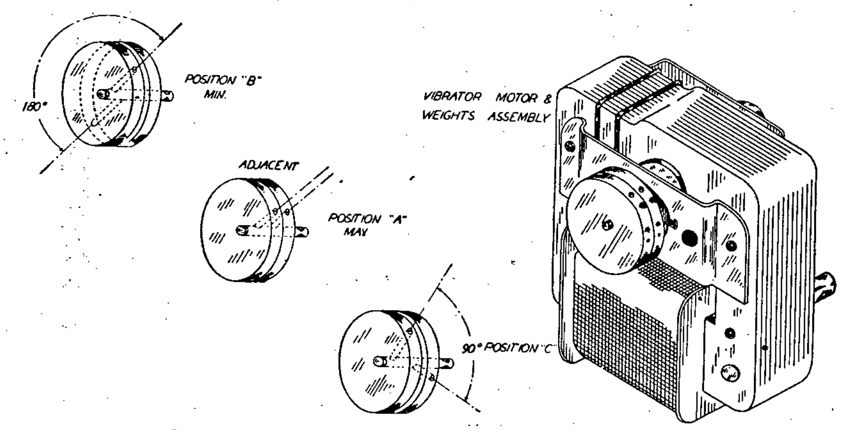


FIGURE 114.—Vibrator motors, positioning of weights.

c. The Telegon oscillator is mounted in the base of the trainer on the lower platform. It has two electrical leads connected to it: the 110-volt, 60-cycle input lead, and the 80- to 90-volt, 700- to 800-cycle output lead. The purpose of this unit is to provide the necessary voltage and frequency of current for operating the remote indication system.

d. The external wiring of the Telegon system is shown in figure 116 ① and ③ and the internal wiring connections are shown in figure 116 ② and ④. Figure 116 ② is a top view of a Telegon unit with the end bells and case removed showing the arrangement of the terminals. This unit is inclosed in a steel shell. Aluminum end bells, which complete the case, are held by four brass clamp screws. Figure 116 ④ is a cross-sectional view of a Telegon unit. The unit consists of a spool assembly, four terminals and two terminal insulators, the shell (S) and two end bells. The spool assembly contains the shaft assembly (K),

the primary coil (M), and the phase windings (F–F′). The four terminals are connected to the primary coil and the phase windings.

e. Operation.—The primary coil (M) (fig. 116 ④) is energized from

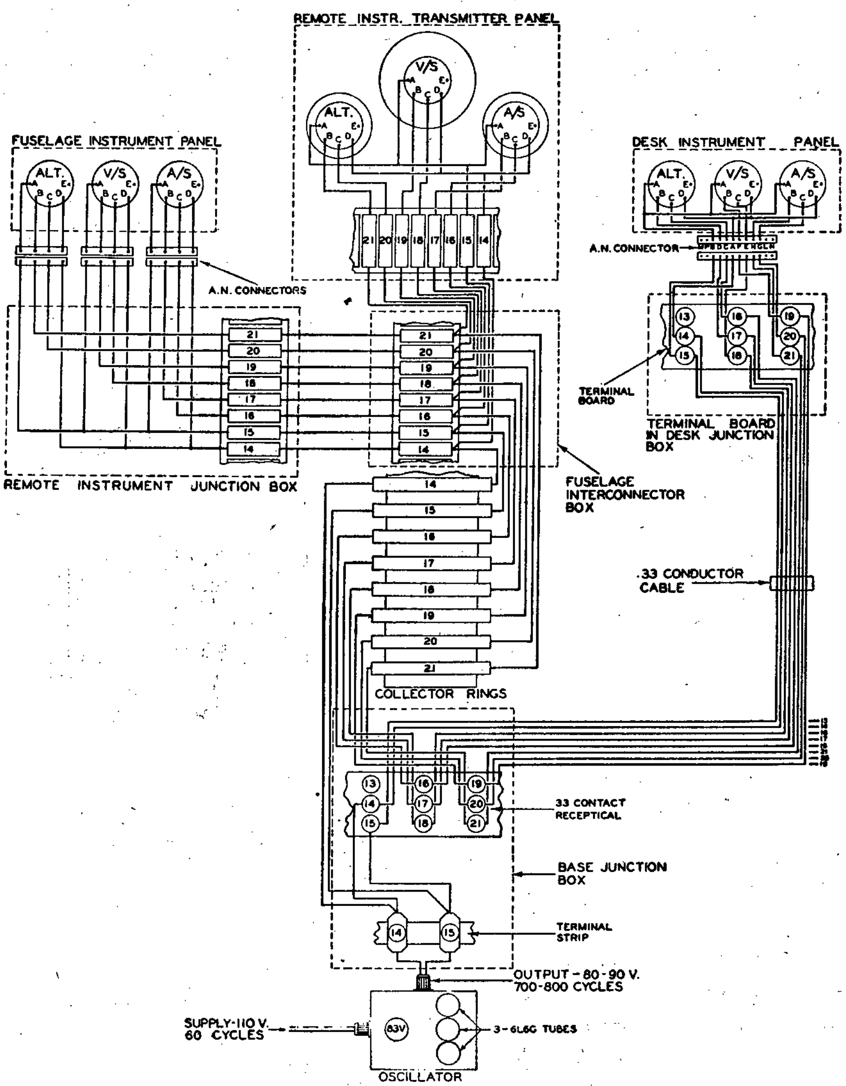


FIGURE 115.—Complete wiring Telegon system, schematic.

an external a-c source (oscillator output), the flux magnetizing the center section of the shaft assembly (**K**) and the vanes. The magnetic circuit is completed through the outer shell (S). When the shaft assembly of the transmitting unit is rotated, the induced magnetic field

surrounding the vanes is also rotated. This field pattern induces a voltage in the phase windings (F–F′), the voltages being proportioned according to the geometric alinement of the flux to the phase windings. The voltages thus induced give rise to proportional currents which flow in the phase winding circuits of both the transmitting and the indicating units, setting up a flux pattern in the indicating unit identical to the pattern in the transmitting unit. The field flux in the indicating unit reacts with the vanes (which are magnetized from the same source as the transmitting unit), causing the shaft assembly to assume the same angular position as that of the transmitting unit.

f. If afforded proper care and handling the Telegon system will function almost indefinitely. *Under no circumstances should the actual Telegon unit be removed from its case or dissassembled unless there is a definite indication that the trouble is located in the unit.* If trouble should develop it will usually be found that the fault lies in the electrical cables connecting the transmitting unit to the indicating unit.

g. Figure 115 shows a wiring diagram of the complete Telegon system. The transmitters are mounted on what is known as the "transmitter panel," mounted in the rear of the trainer behind the pilot's seat and facing toward the rear.

h. The armature of each transmitter motor is connected mechanically to the needle shaft of the instrument that it serves. The three instruments that are in the Telegon system all work the same; hence, only the air speed indicator will be explained in detail. Bearing in mind that the air speed indications are affected by attitude and/or throttle setting, refer to figure 117. It can be seen that within the air speed transmitter housing is an air speed indicator mechanism that has had the indicating needle and face removed, and the needle shaft (A) lengthened. Shaft (A) is connected mechanically to shaft (B), which is the armature shaft of the air speed transmitter. (Shafts (A) and (B) are in reality one single continuous shaft.) Now it can be seen that the air speed indicator, within the transmitter, no longer gives indication, but rather serves as a driving unit for the transmitter motor. As the driving unit causes the transmitter motor armature to rotate, it, in turn, causes a like rotation of the armatures of each of the other two motors. The armature shafts (C) of the receivers extend through air speed indicator faces and have an indicating needle mounted on their ends. Any rotation or movement of the receiver armatures results in a movement of the indicator needles and, consequently, an indication of air speed.

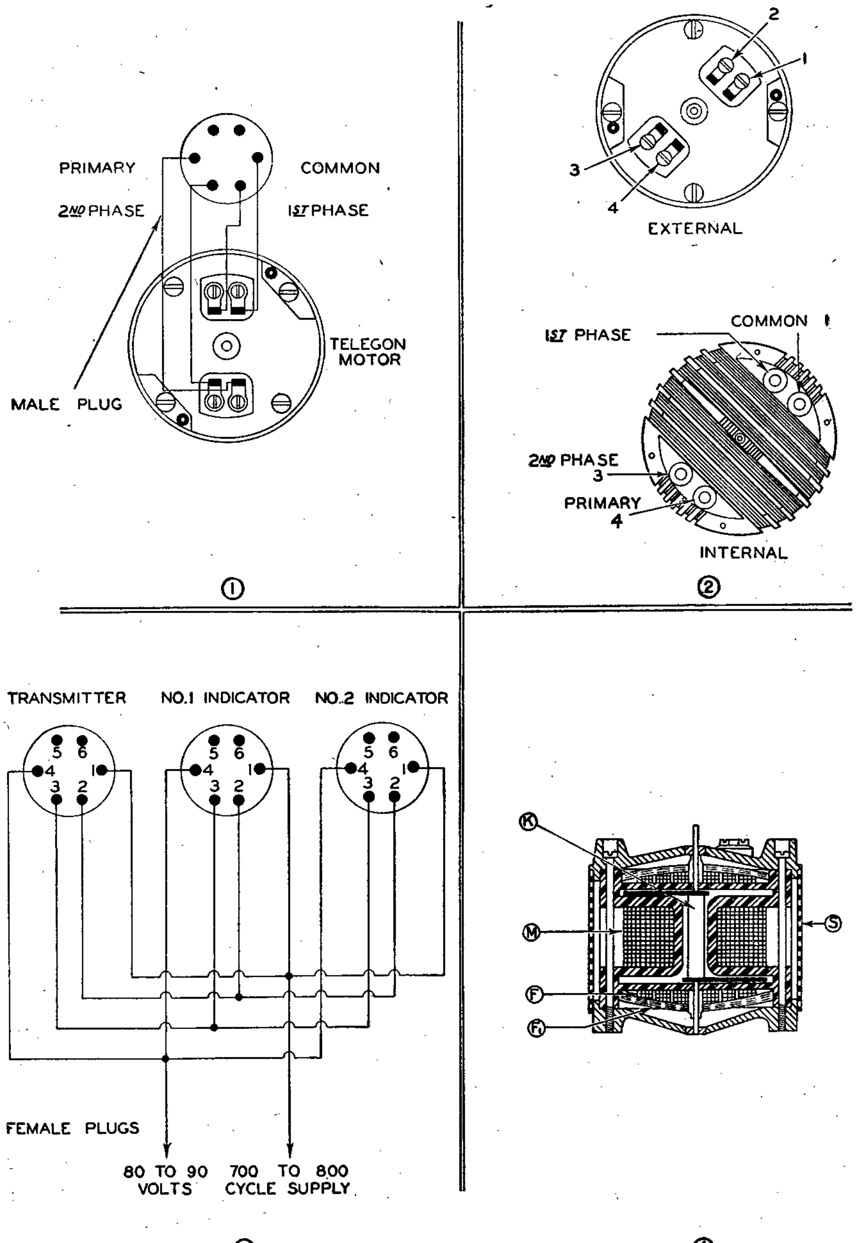


FIGURE 116.—Telegon system.

i. The only equipment required for testing is an ohmmeter and a pair of picks or other suitable contacts. In the event of unsatisfactory operation of the Telegon system, the following points should be checked before removal from the instrument panel:

(1) Line from source of supply to oscillator.

(2) Line from oscillator to junction box.

(3) Line from the transmitter plug to the indicator plug. This may be done by placing picks on similar terminals in each plug.

j. If the trouble is not found to be in the lines, the instrument should be removed from the panel and the following operations performed:

(1) Test the transmitter and indicator at the outlet plugs for the required resistances given in the table below. To test for the required resistances, place one pick on the common, or No. 1, terminal, and the other one on each of the three remaining terminals successively, and note whether the values obtained are within the limits.

Winding	*Ohms*
Primary	225–300
Phase 1	900–1100
Phase 2	900–1100

(2) If the required resistances are obtained in both the transmitter and indicator, the only possible trouble is that the pointer of the mechanism and the fork of the transmitter are not engaged. To correct this it will be necessary to remove the transmitting unit from the mechanism and engage the pointer and fork. *Before removing a transmitter or indicator unit from its case, consult instructions for the individual instruments.*

(3) If the required resistances are not obtained, check the lines between the plug and the terminals to determine whether the fault lies there or between the terminals and the windings.

(4) If the circuit is found to be open between a terminal and a coil the unit should be replaced by a new one. (If an attempt is made to reconnect a broken terminal lead to the winding, great care must be taken in removing the end bells and in putting them on again, to avoid damage to the shaft.)

k. Oscillator.—The function of this unit is to supply 700- to 800-cycle current for the remote indicating instruments. It utilizes a type 83V rectifier tube, and three 6L6G tubes; one as an oscillator and the other two as amplifiers to increase power to the necessary level for proper operation of the instruments. Power supply to the Telegon oscillator should be 110- to 115-volts, 50- to 60-cycle fre-

quency. The output of the unit should be 80 to 90 volts, 700 to 800 cps. The voltage must be measured under full-load condition (all remote instruments properly connected). Voltage can be regulated by adjustment of the sliding contact on resistor R7. (See fig. 118.) If a suitable meter is not available, the 700- to 800-cycle frequency may be checked by touching one tip of a pair of headphones to one side of the output and comparing the tone with any source of a 700 to 800 cps, such as a tuning fork or some musical instrument. The frequency may be adjusted by slight changes in the capacity of condenser C3. On rare occasions it has been necessary to vary the value of condenser C6 from as little as .5 to as much as 1.5 mfd to obtain the correct output. This change should not be made, however, until everything else is proved perfect.

l. Telegon oscillator test data.—These voltage tests must be made with exactly 115-volt input to the oscillator, with all instruments properly connected. During normal operation, voltages should not vary more than + or −5 percent. Voltage variation of more than 10 percent should be carefuly investigated.

Oscillator tube

Prong #3 to ground, 220 volts d-c.
Prong #4 to ground, 65 volts d-c.
Prong #5 to ground, −28.5 volts d-c.
Prong #2 to #7, 6.3 volts a-c.
Prong #3 to ground, 200,000 ohm.
Prong #4 to ground, 700,000 ohm.
Prong #5 to ground, 400,000 ohm.

Amplifier tubes

Prong #3 to ground, 345 volts d-c.
Prong #4 to ground, 220 volts d-c.
Prong #5 to ground, 0 volts d-c.
Prong #7 to ground, 6.3 volts a-c.
Prong #3 to ground, 210,000 ohm.
Prong #4 to ground, 200,000 ohm.
Prong #8 to ground, 500 ohm.

Rectifier tube

Prong #1 to ground, 355 volts d-c.
Prong #2 to ground, 315 volts a-c.
Prong #3 to ground, 315 volts a-c.
Prong #2 to #3, 690 volts a-c.
Prong #1 to #4, 4.9 volts a-c.
One end of resistor R7 to ground, 0; other end to ground, 35 volts d-c, with oscillator on.

Condensers	*Resistors*
C1, .05 MFD—1000 V.	R1, 500,000 ohm, 1 watt.
C2, .001 MFD— 400 V.	R2, 400,000 ohm, 1 watt.
C3, .05 MFD—1000 V.	R4, 200,000 ohm, 1 watt.
C4, 16. MFD— 450 V.	R5, 10,000 ohm, 25 watts.
C5, 4. MFD—1000 V.	R6, 500 ohm, 50 watts
C6, 1. MFD— 600 V.	R7, 500 ohm, 50 watts.

NOTE.—C3 capacitor is adjusted at the factory to tune the oscillator frequency to between 700 and 800 cycles. This is a combination of two condensers, the combined capacity of which may vary to as much as .09 MFD.

NOTE.—To be used with wiring diagram (fig. 118).

40. Wind drift mechanism.—*a. Operation.*—The wind drift mechanism serves to introduce the effect of various wind directions and velocities on trainer heading and ground speed at cruising and other air speeds, as traced by the recorder. In order that the pilot working in the trainer may be subject to the same conditions as he would be in the air, it is necessary to provide simulated wind conditions. These conditions appear in the behavior of the recorder. The movement of the recorder on the chart simulates travel over the ground under wind conditions. This movement is governed by the wind drift mechanism, located in the base of the trainer. The mechanism consists of an assembly of gear trains so arranged that when the various elements of the wind drift problem are led into it, the output is track and ground speed. In operation, wind direction and wind velocity are applied to the trainer heading and air speed by the instructor, either before or during a problem. This is accomplished by turning the wind velocity and wind direction cranks on the right-hand side of the desk to the desired settings. The wind velocity dial at the desk goes from a zero setting to 60 miles per hour wind velocity; the wind direction from 0° through 360°.

b. Conditions to be represented in terms of wind triangle.—The wind drift mechanism solves the wind triangle automatically. Into it are put (1) heading—by trainer rotation; (2) air speed—by throttle setting and trainer attitude; (3) wind direction—manually; and (4) wind velocity—manually. Out of it come track and ground speed. The three sides of the wind triangle are usually drawn and labeled for graphic solution in the form (1) heading and air speed; (2) wind direction and velocity; (3) track and ground speed; and are all subject to change, both in direction and length. However, in the wind triangle used in the wind drift mechanism (fig. 120), one of the sides *AB* is fixed in direction, and for mechanical reasons the wind triangle

elements are arranged as follows: (1) air speed *AB*; (2) wind speed *BC*; and (3) relative wind angle *ABC*, the latter being the angle between the heading and the wind direction. From these are pro-

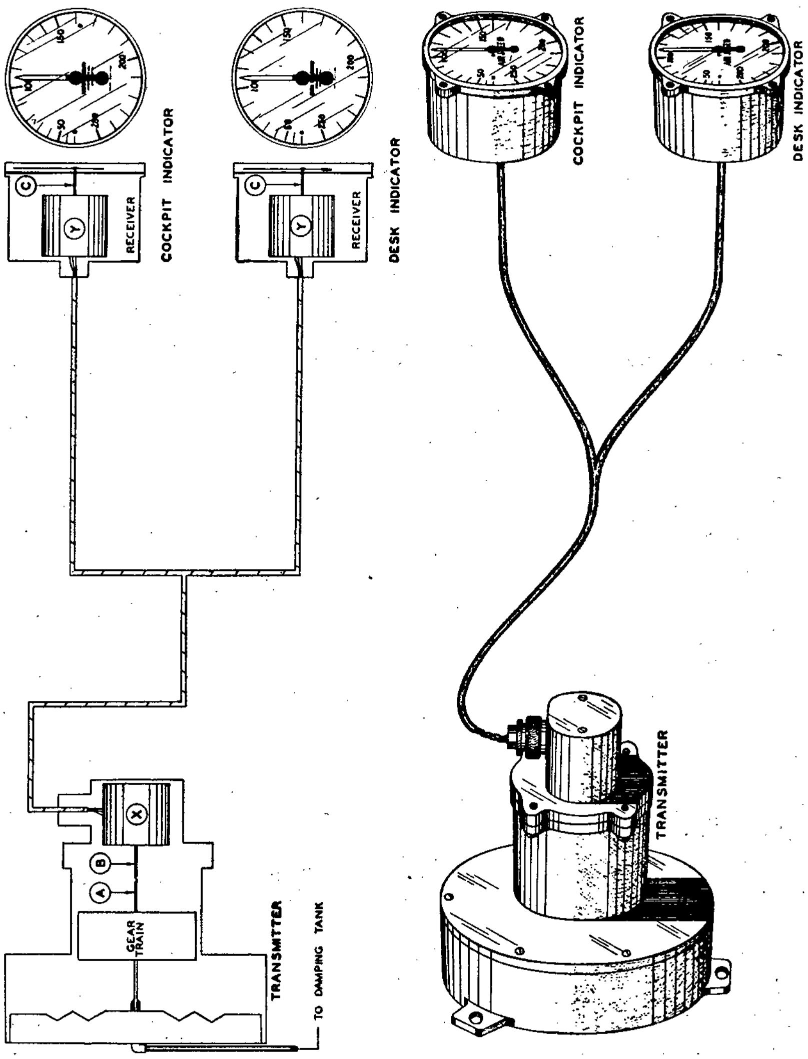


FIGURE 117.—Telegon system.

duced the ground speed *CA* and the drift angle *CAB*. To illustrate how the wind triangle in the wind drift mechanism meets the necessary conditions, an aircraft in flight on a north heading at 160 mph air speed encounters a wind from the east blowing at 60 mph. The relative wind angle is 90° right. The aircraft, under these con-

ditions, will be blown to the left at an angle of 20° to the heading, that is, the drift angle will be 20° left. Consequently, the track will be $360° - 20°$ or 340°. The ground speed will be 171 mph.

c. Mechanical wind triangle in mechanism.—The wind may be thought of as always blowing down the side *BC*. *AB* may be thought of as representing the heading of the aircraft relative to the wind. Angle *ABC* is the angle which the heading of the aircraft makes with the wind, or the relative wind angle. Since the direction of the side *AB* is fixed, this angle is varied by rotating the wind bar *BC* (fig. 119). When the trainer rotates (change of heading), the wind bar rotates in the same direction as the trainer. When the wind direction is altered, the bar rotates in the opposite direction to the shifting wind. The two movements are applied simultaneously to the wind bar through a differential R. W. A. D. (relative wind angle differential). (fig. 120.) Heading is led into the wind drift mechanism through gears at the bottom of the trainer main spindle through flexible connections as shown in figure 120, which drive shaft (X) and wheels (M) and (N); wind direction from the instructor's handcrank through shaft (Z). The output of R. W. A. D. is applied to the wind bar through shaft 3 and gears R, 4 and 5. As the wind bar rotates, the rack (AC) applies the drift by its pivoting movement at A (fig. 120) and the ground speed by its sliding motion through A. Figure 121 gives a side view of the same parts, and in addition shows how the two distinct drives are taken off the wind triangle rack: wind triangle pinion drive No. 1 and wind triangle pivot drive No. 2.

d. Application of drift and ground speed movement.—(1) *Pivoting or drift movement.*—One required output of the mechanism is the "track." Since the pivoting movement at A gives drift, to obtain the track it is necessary to add the heading to the drift algebraically. This is done at the track differential (T. D., fig. 122). The drift angle is taken from the wind triangle pivot at A and the heading from the shaft (X). The two movements, heading and drift angle, are led into the differential T. D. and coordinated. The out—track—is led to the master teletorque. The stages by which the track is arrived at are as follows:

(*a*) *Heading component.*—Gear attached to trainer spindle to pinion on universally mounted shaft through bevel gears, to primary drive (X) of track differential in wind drift mechanism.

(*b*) *Wind drift component.*—Gear wheel (G) bolted to the main wind slide pivot through pinion (H) to gear (K), to the secondary drive of the track differential (J).

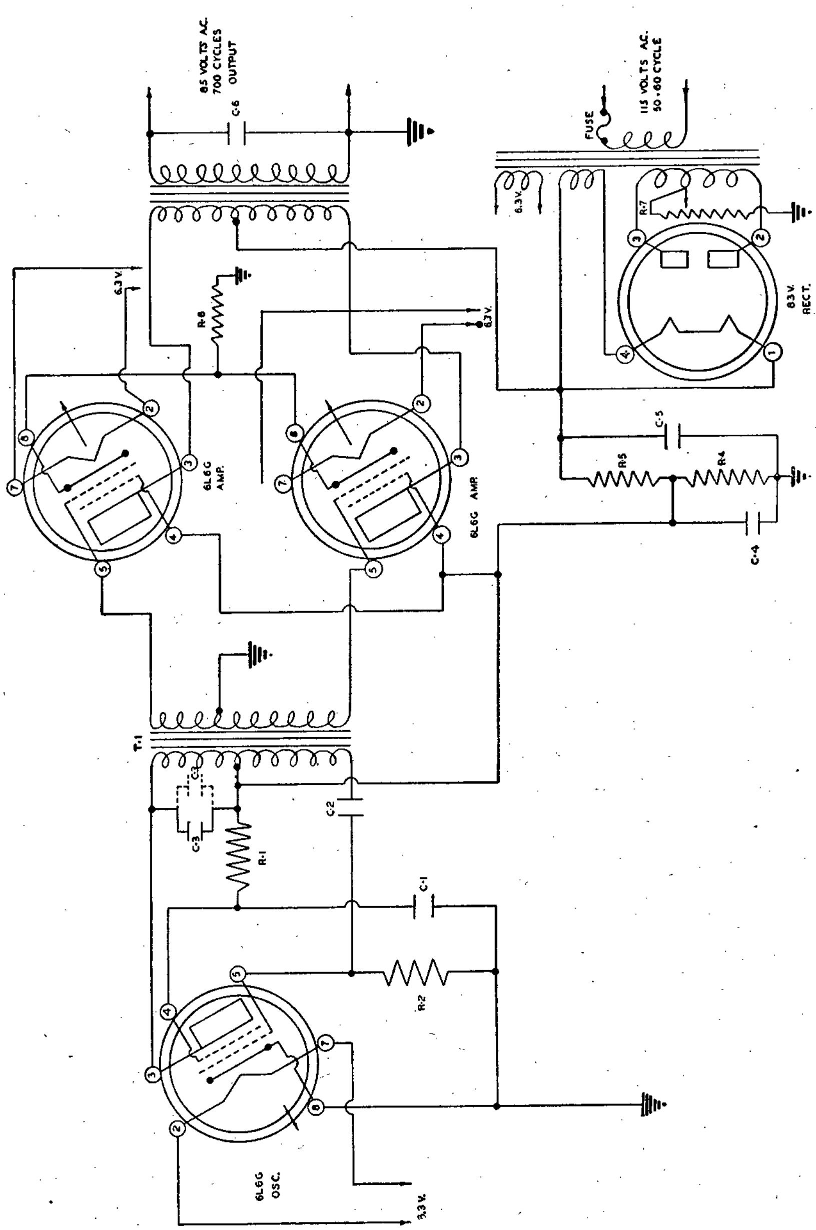


FIGURE 118.—Telegon oscillator circuit.

(c) The output shaft (G) of the differential drives the master teletorque which in turn controls the recorder teletorque, thus controlling the direction of travel, or track of the recorder.

NOTE.—In order to remove back lash in the gear trains, a constant speed motor is geared in at wheel 9 (fig. 122).

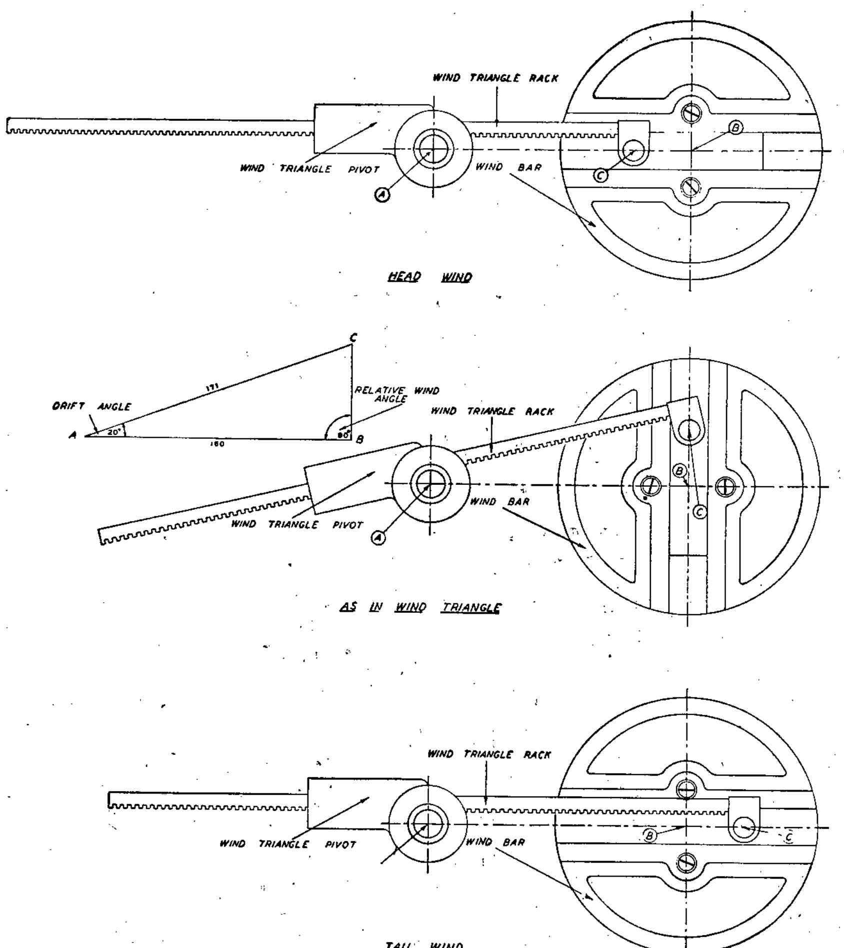


FIGURE 119.—Wind triangle position.

(2) *Application of the sliding or ground speed movement.*—As illustrated from the wind triangle, ground speed is obtained by the sliding movement of the wind triangle rack through A. However, it will be observed from figure 123 that it is not possible to take off from the pinion (F) at (A) the sliding motion alone. When given

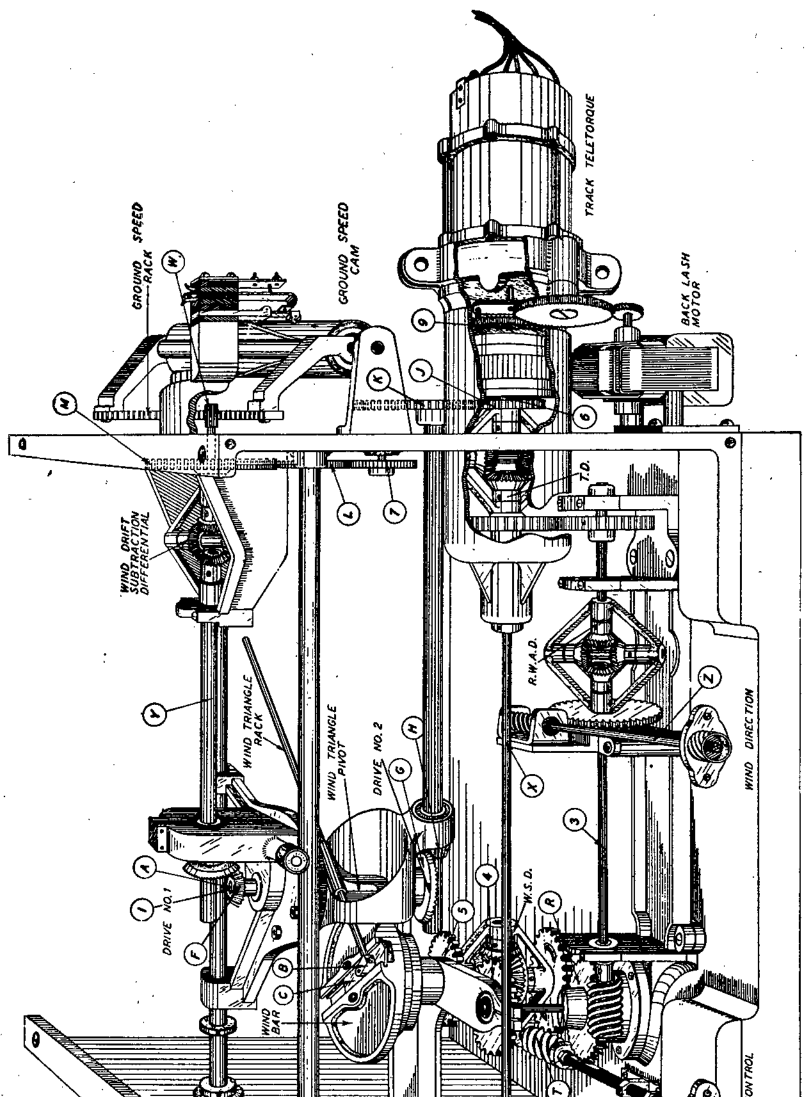


FIGURE 120.—Wind drift mechanism.

sliding motion, the rack not only slides but pivots at the same time, giving an additional movement to the pinion (F), which would represent additional wind drift. To obtain the ground speed alone, the drift must be removed. This is done by means of a differential—The wind drift subtraction differential (WDSD) (fig. 123). Into one side of the differential is led the combined pivoting and sliding movement of the wind triangle rack through shaft (Y). Into the other side of the differential is led the pivoting motion alone, through "H," "7," "L," and "M." This latter drive works against the drive from the wind triangle rack. Thus, the output of the differential is the sliding plus the pivoting motion, less the pivoting motion which

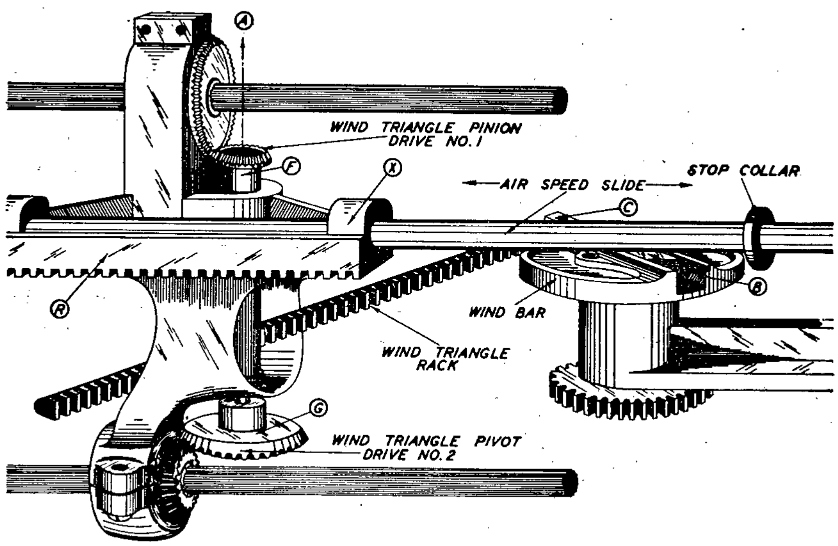


FIGURE 121.—Main wind slide.

equals the sliding or ground speed movement alone. The output is applied to pinion (W). The ground speed movement is used to control the speed at which the recorder travels over the chart, or actually the ground speed.

e. Variation of air speed and wind speed.—(1) *Air speed control.*—(*a*) The air speed component of the triangle is varied by altering the distance between the pivot (A) and the pivot of the wind bar (B) (fig. 121). The wind bar pivot is fixed. The wind triangle pivot housing is mounted on a slide (air speed slide) and is free to move toward or away from the wind bar pivot. The pinions (G) and (F) are free to slide on their splined shafts. The position of the wind triangle pivot on the air speed slide is controlled by a two-way

"follow up" motor, which acts through pinion (D) and rack (R), the rack being attached to the wind triangle pivot housing. (See fig. 124).

(*b*) The direction and length of time this follow up motor runs is controlled by a rotary switch (O). One side of the rotary switch (the contact point) is attached to a pulley around which is led a cable. This cable passes over pulleys through the main spindle into th fuselage to the air speed reversing lever. Changes in air speed move the cable, which is under tension in one direction because the pulley is spring loaded. The other side of the rotary switch, which consists of two plate sections, is attached to the pinion (D). Contacting each plate section (one for clockwise, the other for counterclockwise rotation of the motor) is a brush (C), which carries one side of the circuit to the "follow up" motor. (The periphery of each plate is cut away into a cam section to prevent running the motor beyond the limits of the rack.)

(*c*) *Principle of operation.*—When the pulley rotates (due to change in air speed), the contact point on the gear (E) makes contact with one of the plates attached to the disk on pinion (D). This completes the circuit to the "follow up" motor which rotates. This turns the pinion (D) which drives the rack and the wind triangle pivot attached to it. The disk with the plates also rotates with the pinion, until a gap between the plates reaches the contact point on the gear wheel (E), stopping the follow up motor.

(2) *Wind speed control.*—(*a*) Wind speed is varied by altering the distance between "B" and "C." The slotted wind bar accommodates a rack which slides in the bar. The rack is driven by a pinion (Q) in the center of the wind bar (fig. 125). As the pinion revolves, the crank pin at (C) moves toward or away from the center of the wind bar, decreasing or increasing the wind speed.

(*b*) However, were the drive to the rack a direct one, the setting of the crank pin would be disturbed whenever the wind bar revolved. (The pinion at "B" remains stationary and the rack rotates about it, causing the pinion to drive the rack). To allow for the fact that the wind bar revolves with the trainer heading, a differential is provided, which turns the pinion at "B" in the same direction as that in which the wind bar is revolving. From figure 125 it can be seen that when the wind bar rotates, its movement will be transmitted through wheels (R), (U), and (V), through the primary drive of the differential to the pinion at (B), the drive being reversed at wheel (S). Thus, the rotation of the trainer is prevented from having any effect on the setting of the crank pin. The wind speed is set by hand by worm gear (T) through the secondary drive

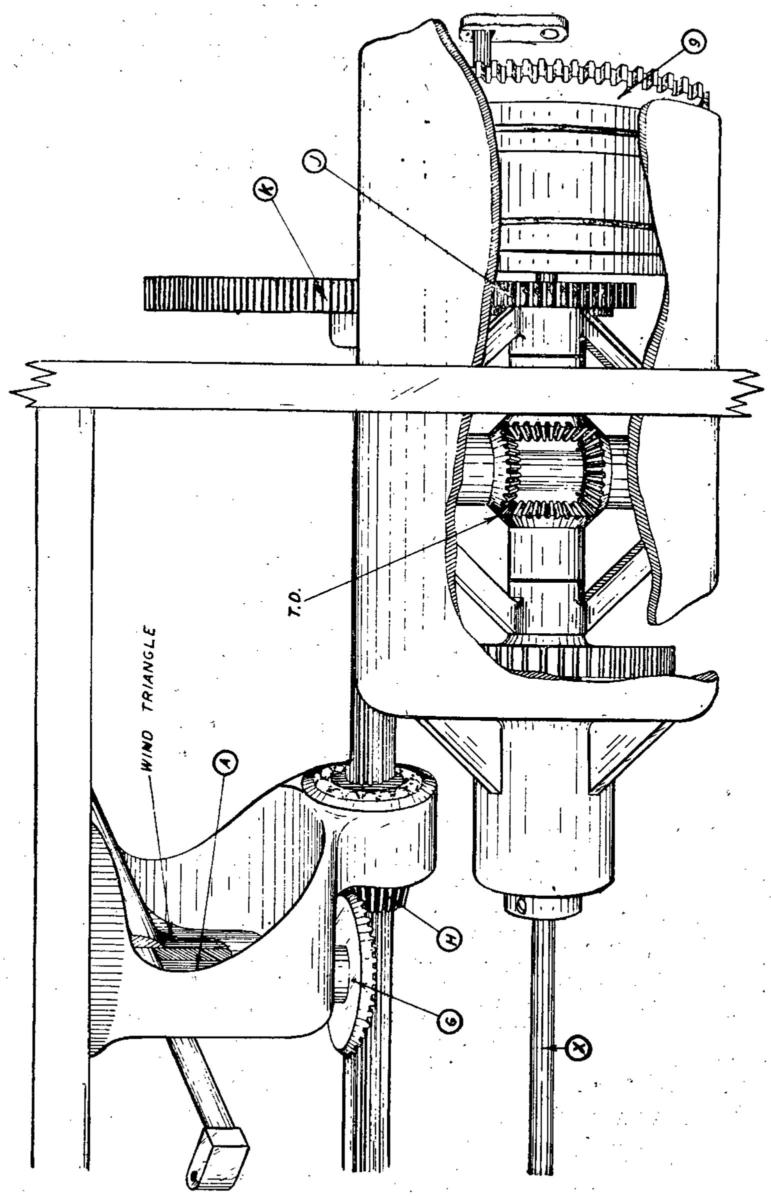


FIGURE 122.—Track differential.

of the differential to the pinion at "B." The wind may be varied from zero (when the crankpin (Q) is directly over the center (B) to one-half the normal gliding speed of the trainer, when the rack is fully extended and the pin is at the furthermost possible distance from (B).

(3) *Application of the wind drift mechanism output to the recorder.*—(*a*) The wind drift mechanism output consists of two movements—one represents change of track, the other change of ground

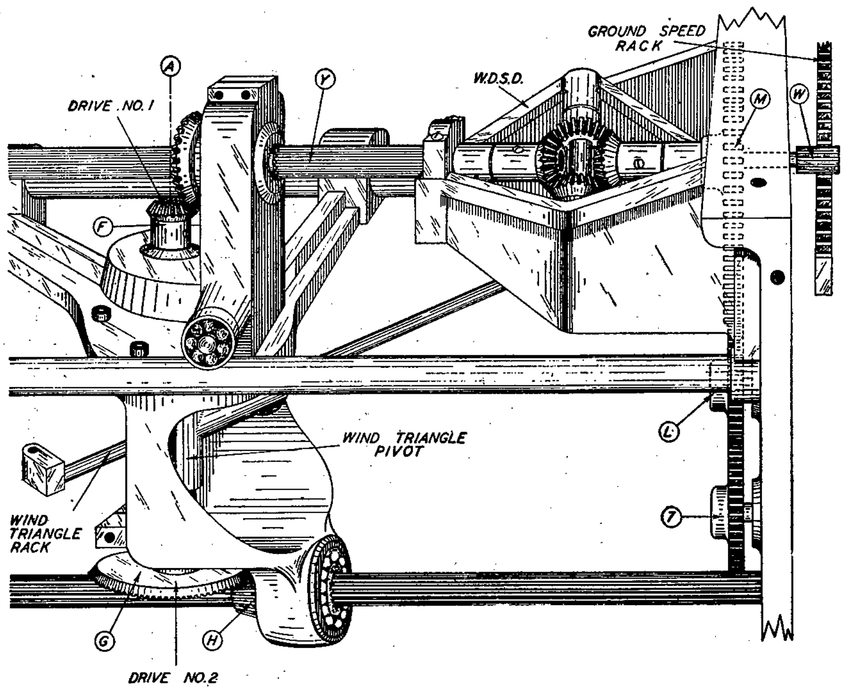


FIGURE 123.—Wind drift subtraction differential.

speed. The movements are transmitted to the recorder by means of a teletorque unit and an intermittent motor control for the telechrons. The recorder is similar to the ones in use on C-2 and C-4 trainers. The drive wheels are given motion by means of two telechron motors, while both drive and inking wheels are rotated by means of a teletorque in the center of the recorder.

(*b*) With zero wind, the recorder teletorque turns the wheels to the same direction as the trainer is headed (provided the recorder has been synchronized properly with the trainer).

(*c*) This is accomplished through the master teletorque on the outside of the wind drift mechanism case. Rotation of the trainer rotates the master teletorque armature which rotates the recorder

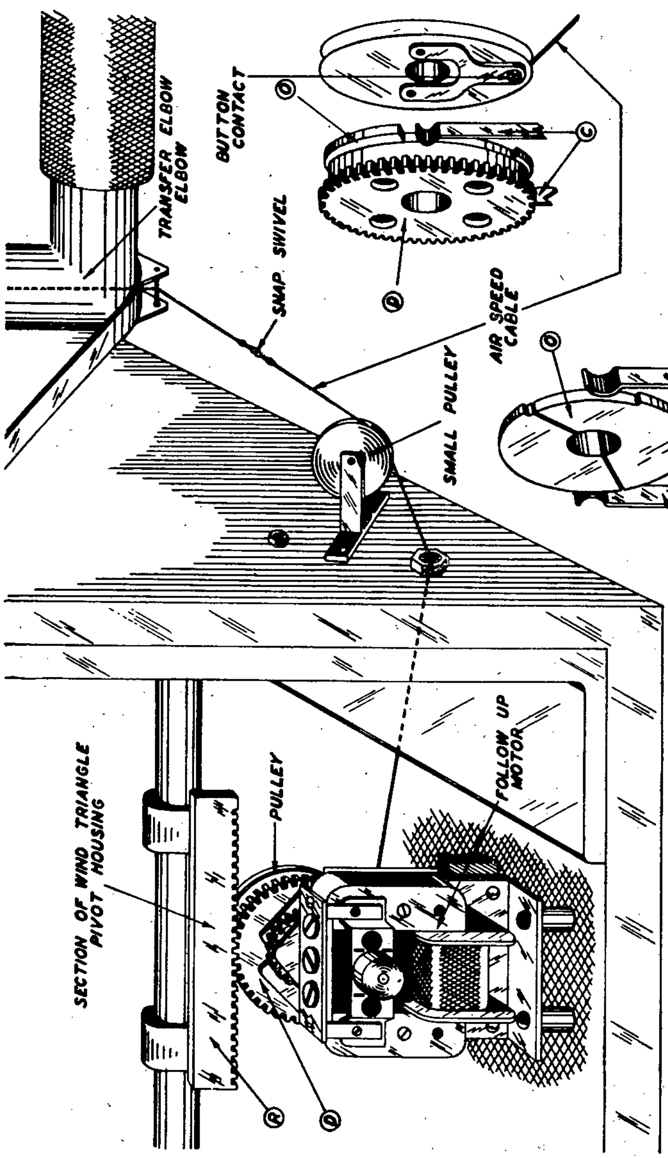


FIGURE 124.—Air speed control.

teletorque armature. When wind is cranked in, the drift angle is taken from the main wind slide pivot at (A) (fig. 121). The two movements, heading and drift angle, are then led to a differential and there coordinated. The output—track—is led to the master teletorque.

(*d*) The stages by which the track is arrived at are as follows:

1. Heading component.—Gears and linkage at spindle in base of trainer, to primary drive of heading—track differential (D) in the wind drift mechanism.

2. Wind drift component.—Gear wheel (G) bolted to the main wind slide pivot, through pinion (H) to gear (K), to secondary drive of the heading—track differential. The output shaft of the differential drives the master teletorque, which in turn controls the recorder teletorque.

(4) *Ground speed drive.*—(*a*) To obtain variable recorder speed to simulate varying ground speed, the circuit which supplies the power (current) to the two recorder telechrons is made intermittent. The length of time the circuit remains broken or completed determines the ultimate distance that the recorder will travel in any given time.

(*b*) The "making" and "breaking" of the current is the function of the ground speed drive. (See fig. 126.) Constant speed motor (E) through gears rotates splined shaft (D), which keeps cam roller (C) turning constantly. The brackets for the cam roller are attached to rack (B), motion to which is given by pinion (W). Pinion (W) is governed by the ground speed component of the triangle. The position of the rack determines the position of the cam roller on the splined shaft. The small roller (G) on the fixed "make and break" (or switch) points block (F) then allows the points to open and close as the small roller (G) rides on the cam roller (C). The length of time the points are open depends on the position of the cam roller on the splined shaft, which is dependent on the ground speed output of the wind drift mechanism.

f. Summary.—(1) *Four racks.*—The wind drift mechanism utilizes four racks:

(*a*) *Wind triangle rack.*—Through the wind triangle rack the wind triangle pivot receives the wind drift movement, and the wind triangle pinion receives the ground speed movement.

(*b*) *Ground speed rack.*—This rack is driven by a pinion which moves in proportion to the value of the changing ground speed of the simulated aircraft. The rack determines the position of

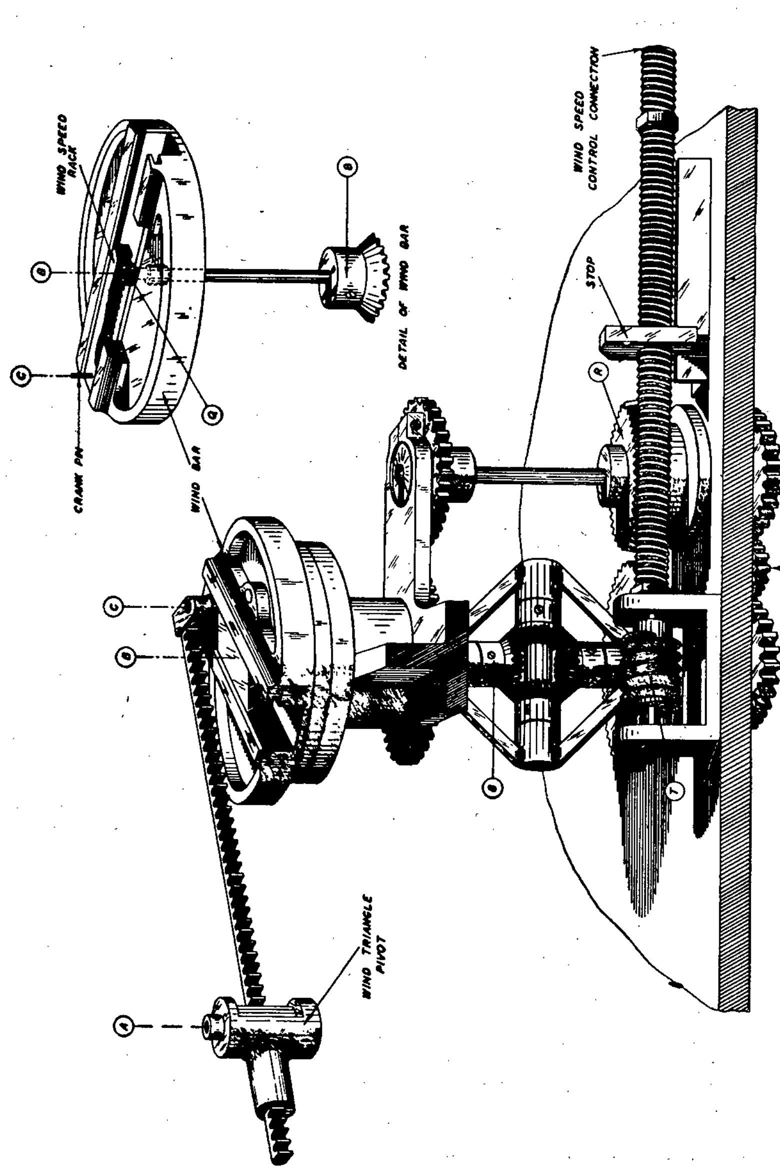


FIGURE 125.—Wind speed control.

the cam roller which provides for an intermittent control of the recorder telechron drive motors.

(*c*) *Wind speed rack.*—The wind speed rack is the agent by which the length of the wind speed vector is varied. Set in the wind bar, it is driven by a pinion, special provision being made for the wind bar to rotate without disturbing the setting of the rack.

(*d*) *Air speed rack.*—"R" in figure 124 is driven by the air speed "follow-up" motor and determines the value of the air speed side of the triangle.

(2) *Four differentials.*—In all, the wind drift mechanism utilizes four differentials. The following is a summary of their uses:

(*a*) *Track differential.*—The drives: heading (from the heading gear box); wind drift triangle pivot. The output: track (relayed to master teletorque).

(*b*) *Wind drift subtraction differential.*—The drives: ground speed plus drift (sliding and pivoting movement of main wind slide rack); wind drift (wind triangle pivot). Output: ground speed (relayed to master teletorque).

(*c*) *Wind speed differential.*—The drives: wind bar rotation; wind speed control. Output: wind speed (relayed through wind speed rack to wind speed crank pin).

(*d*) *Relative wind angle differential.*—The drives: trainer heading (from heading gear box); wind direction control. Output: relative position of heading to wind direction.

g. Maintenance and adjustment.—The mechanical parts of the wind drift mechanism require no servicing. Once the unit is installed, the mechanism should function satisfactorily until it wears out. All bearings are either oilite or provided with lubricant sufficient for the life of the unit. In the event of failure or fracture of any particular piece in the internal mechanism, and entire wind drift mechanism should be returned to the manufacturer for replacement. The electrical units, such as the rotary switch for airspeed control may, however, be serviced by any good electrician who has had experience with this type of switch. Should the teletorques fail to function, they can be replaced by new units and correctly synchronized. The constant speed ground speed drive motor is a telechron and should also not require servicing, since the gear box is provided with enough lubricant to last a lifetime.

h. Adjustment.—*a.* In the original installation of the trainer and during subsequent weekly or periodic checks, the length of recorder travel at cruising should be checked against the cruising air speed indication and adjustment for correct travel should be made if

required. With the wind velocity set to zero, the recorder should travel .845 inch per minute. Adjustment is made by varying the distance *AB* in figure 119 or figure 124, by lengthening or shortening the electric throttle cable at the snap swivel outside the wind drift unit between it and transfer elbow. A more definite check may be obtained by measuring the distance betwen the end of the air speed slide bracket at "X" and the stop collar. (See fig. 121.) At indicated cruising air speed, this distance should be adjusted to $^{15}/_{16}$ inch by the means described above. As a matter of interest 10 mph of recorder movement is represented by—

(1) $^{5}/_{32}$-inch movement of the air speed slide.

(2) $^{7}/_{64}$-inch movement of the electric throttle cable.

(3) $^{3}/_{32}$-inch side movement of the ground speed cam.

i. Methods in detail.—(1) *No. 1.* (*a*) Check the air speed system for correct adjustment and for air speed regulator spring tension. Adjustment to the wind drift mechanism cannot be made unless this is done first.

(*b*) Check wind velocity for zero setting (as a double check see that point (C) is over point (B)). (See figs. 119 and 121.)

(*c*) Set air speed indicator to 160 mph (trainer locked level, "floating").

(*d*) Run recorder from a definite starting point, 5 (or 10) minutes by a stop watch.

(*e*) Measure the length of the line and divide by the number of minutes for the run.

(*f*) If the run per minute is longer than .845 inch loosen the setscrew at the snap swivel between the transfer elbow and the wind drift mechanism and allow the cable to move slightly into the wind drift box. If the distance per minute is shorter than .845 inch, loosen the setscrew and pull outward slightly on the cable. ($^{1}/_{8}$-inch movement of the cable equals 10 mph of recorder travel.)

(2) *No. 2.*—(*a*) The first three steps are the same as in (*1*) (*a*), (*b*), and (*c*) above.

(*b*) Check distance between end of air speed slide and the stop collar face. This should measure $^{15}/_{16}$-inch. If the distance is less, loosen the throttle cable and shorten (pull out of the W.D. box) and vise versa.

(*c*) As a double check make the above described 5- or 10-minute run.

NOTE.—Charts used with trainers equipped with the wind drift device must be drawn to scale if the results are to have any meaning. Since .845 inch per minute at 160 mph represents 2.666 mph, 1 inch equals 3.155, or roughly 3.2 miles.

j. Adjustment of contact points (fig. 126).—The points are adjusted at the factory so that at the moment one contact is broken the other contact is made—no appreciable interval existing between supplying the telechrons with either the 110-volt a-c or the 12-volt d-c. Too wide a gap brings about excessive over run or coast. This upsets calibration of the units and destroys the accuracy of the tracking speed. Too close a gap, or simultaneous contact between the two sets of points overloads the line and may blow fuses. The desired adjustment can be made by turning the constant speed motor of the unit over slowly by hand (power off) watching the points as they make and break and screwing in or out on the adjustment (H) and (I). Adjustment (H) positions the ground speed while adjustment (I) positions the d-c break point.

k. Procedure for adjusting wind velocity control.—Turn tail of fuselage toward the desk. Then by sighting down past the side of the fuselage square the fuselage with the base. An inspection window is located on top of the wind drift case in the base of the trainer. Have helper turn wind velocity crank at desk until small pivot (A) (fig. 127), visible through the window, is at outer edge of the wind bar (B) (fig. 127). A positive stop is located in the unit and set at the factory. This should not be forced. Disconnect the flexible cable from the wind velocity crank at the desk. Set dial at desk to "60". Reattach flexible cable and crank the dial to zero. The pivot (A) should now be in the center of the wind bar (B). To synchronize the recorder (flight log) with the wind drift unit—

(1) Switch off the vacuum turbine in the base and turn on the line switch in base junction box.

(2) Turn on the ignition switch on the right side of the instrument panel and then plug in the recorder.

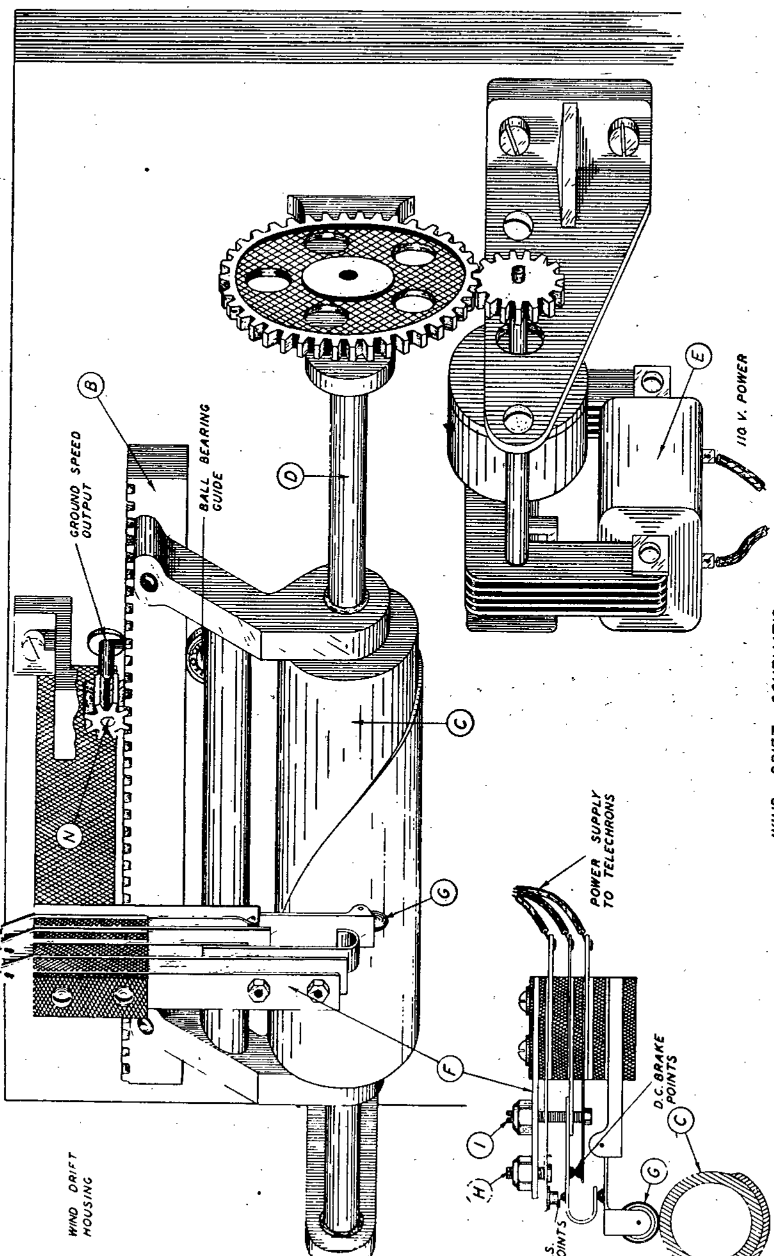
(3) Head the trainer exactly north (tail of fuselage over base junction box and fuselage square with base); rotate the movable dial that has a compass rose graduated on it (0 to 360) until 0 of this scale is opposite the fixed reference pointer.

(4) By means of the three large gears in the recorder, turn the inking wheel until the movable pointer is over 0 in the movable dial and in line with fixed reference pointer.

(5) Let go of the large gears. If the pointer moves away from the 0 it is necessary to correct this in the base of the trainer.

(6) Check that the wind velocity dial at the desk is set at zero.

(7) In the base of the trainer, spring out the pick-up bracket enough so that the gears will clear each other. While holding the bracket out, rotate the small gear until pointer is over the 0 and



WIND DRIFT SCHEMATIC
FIGURE 126.—Ground speed drive.

allow gears to mesh. This operation should not need to be repeated unless at some future time the gears in the base or in the flight log have been disassembled. Next time the recorder is plugged in on the desk, it will only be necessary to rotate the large gears by hand until the pointer agrees with the trainer heading.

(8) Next, crank the wind velocity dial at the desk to maximum wind (60 mph). Check that tail of fuselage is over base junction box, and by sighting down past the side of the fuselage *square the fuselage up with the trainer base.* Looking through the inspection window on top of the wind drift case in the base, have helper turn wind direction crank at desk until the pivot (A) (fig. 127) is away from the center of the trainer and exactly parallel to rack (C) in figure 127③. This is a maximum head wind. The flexible cable on the wind direction coupling at the desk should now be removed, the wind direction dial rotated to zero, and the flexible cable reattached.

NOTE.—Since the above setting has been made at a maximum head wind, it can be noted that the same conditions apply to any trainer heading with a wind from the same direction.

(9) Turn on trainer ignition swich and set the throttle at cruising, making sure both climb and dive valve are closed and trainer is floating in lock straps. The air speed reading must be exactly on cruising for this check, as the whole adjustment of the wind drift unit is based on this first step.

(10) Connect the cable to recorder flight log and let it run a minute or so, to allow telechron motors to warm up. *Handle the recorder carefully.*

(11) Place the recorder on a piece of white paper on the desk and with a stop watch, note travel of recorder in 1 minute, making sure that the air speed is at cruising and both the wind velocity and the wind direction dials at desk are at zero. Use one rpm telechron motor for this check if the trainer is type C–3 and two rpm telechron motors if the trainer is type C–5. Recorder should have traveled $^{27}/_{32}$ inch (.845) in 1 minute. If travel of recorder is short of $^{27}/_{32}$ inch, shorten bronze cable in fuselage by loosening nut (C) on pivot clam (A) (fig. 127②) which is located on top of air speed lever arm, and pull the bronze cable through a bit. Tighten nut and set the throttle at cruising and check recorder again for 1 minute. If the travel of the recorder is over $^{27}/_{32}$ inch (.845), loosen nut (C) (fig. 127②) on air speed lever and loosen cable up a bit. Check the travel of the recorder several times. This is the main adjustment and must be correct so that the changes in the wind velocity and wind direction will be correct.

(12) Decrease the air speed reading to 120 mph by closing the throttle very slowly and allowing the hand on air speed indicator in trainer to fall back to 120 mph. Make sure that the trainer is floating in its straps and that the hand on air speed indicator is right on 120 mph.

(13) Note the travel of the recorder for 1 minute, using stop watch. The recorder should have traveled $^{41}/_{64}$ inch (.640). If this reading is above $^{41}/_{64}$ inch (.640) in 1 minute loosen nut (D) (fig. 127②) on air speed lever arm and move clamp up.

(14) Open and close throttle smartly and reduce air speed to 120 mph and check travel of recorder again. If the travel of the recorder is under $^{41}/_{64}$ inch (.640) in 1 minute, loosen nut (D) (Fig. 127②) on airspeed lever arm and move clamp (A) down a small amount, making sure that nut is tightened up after each adjustment. When this adjustment is correct, check the recorder travel at cruising again for a double check.

(15) The next step is to check wind velocity by adding 20 miles head wind. Do this by turning crank on wind velocity at the desk and setting dial to 20. (The wind direction is still at zero.) Set the trainer at cruising and check travel of Recorder for 1 minute, which should travel $^{47}/_{64}$ inch (.734).

(16) Next, check the wind direction by cranking in a wind direction of 180° at the desk. Leave wind velocity dial at 20. The recorder should now travel $^{61}/_{64}$ inch (.953) in 1 minute (trainer still at locked level and cruising).

NOTE. These two last checks should be correct if the first adjustments were made correctly and serve merely as a double check on previous adjustments.

41. Control box, trainer.—*a.* C-3, C-4, and C-5, model trainers incorporate a control box on the right-hand side of the cockpit, for the purpose of serving as a junction box for the various circuits of the fuselage, and to serve as a mounting for electrical circuit controls.

b. Figure 128 is a drawing of the control box common to C-4 models having mounted on its side, from top to bottom, the call signal switch which, when placed in the "On" position, superimposes a 60-cycle hum upon the signal being used. Its purpose is to inform the desk operator that the student in the trainer wishes to communicate by phone or code with the desk operator. The 60-cycle hum is derived from the 12-volt transformer, which supplies the necessary voltage to the compass deflector circuit. The second control is a variable resistor placed in the phone circuit, and is used by the student, just as the volume control of an aircraft radio receiver, to vary the sound level of the simulated range and aural marker beacon signals. This resistor

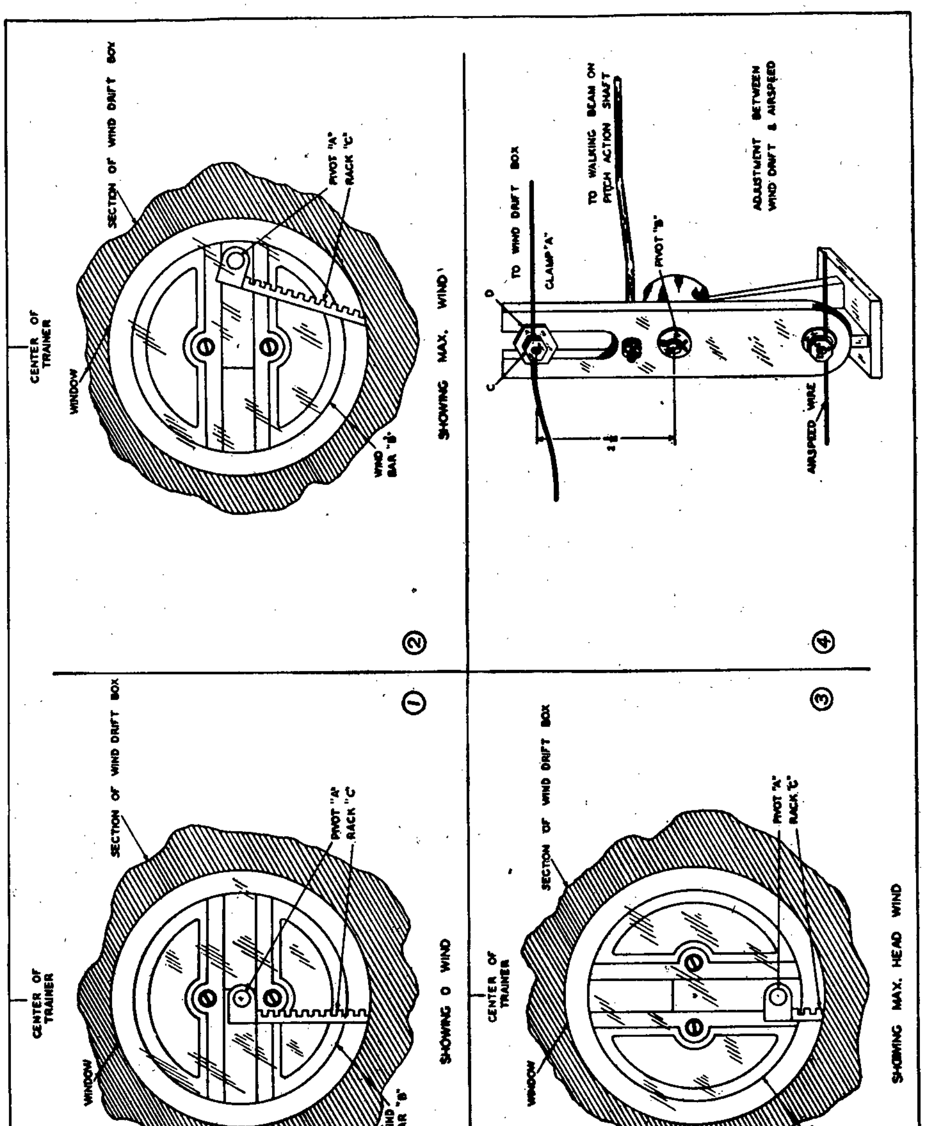


FIGURE 127.—Wind bar and air speed adjustment.

is not in the voice circuit at any time. The third control is a second variable resistor used to control the current flow to the landing path indicator, and so vary the magnitude of its indications.

NOTE. This instrument is common only to C-4 trainers that were manufactured for commercial use originally, and designated by the manufacturer as Special E's. Mounted directly below the landing path volume control is the switch that controls the landing path system mentioned above. Figure 129 shows the internal wiring of this control box.

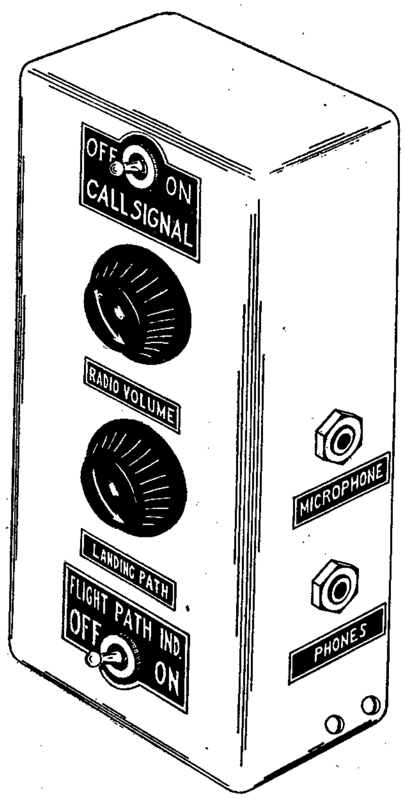


FIGURE 128.—Control box (fuselage C-4 trainer).

c. C-5 Control box.—The fuselage control box (fig. 130) serves as a mounting place for the student's controls not mounted upon the instrument panel as well as a junction point between the instrument panel, interconnector box, fuselage power supply, rudder valve switch, and cockpit light cables. The student's interphone amplifier is also mounted in the fuselage control box. On a shelf within the fuselage control box is mounted the student's interphone amplifier, the student's interphone volume control, and the E relay. The student's interphone

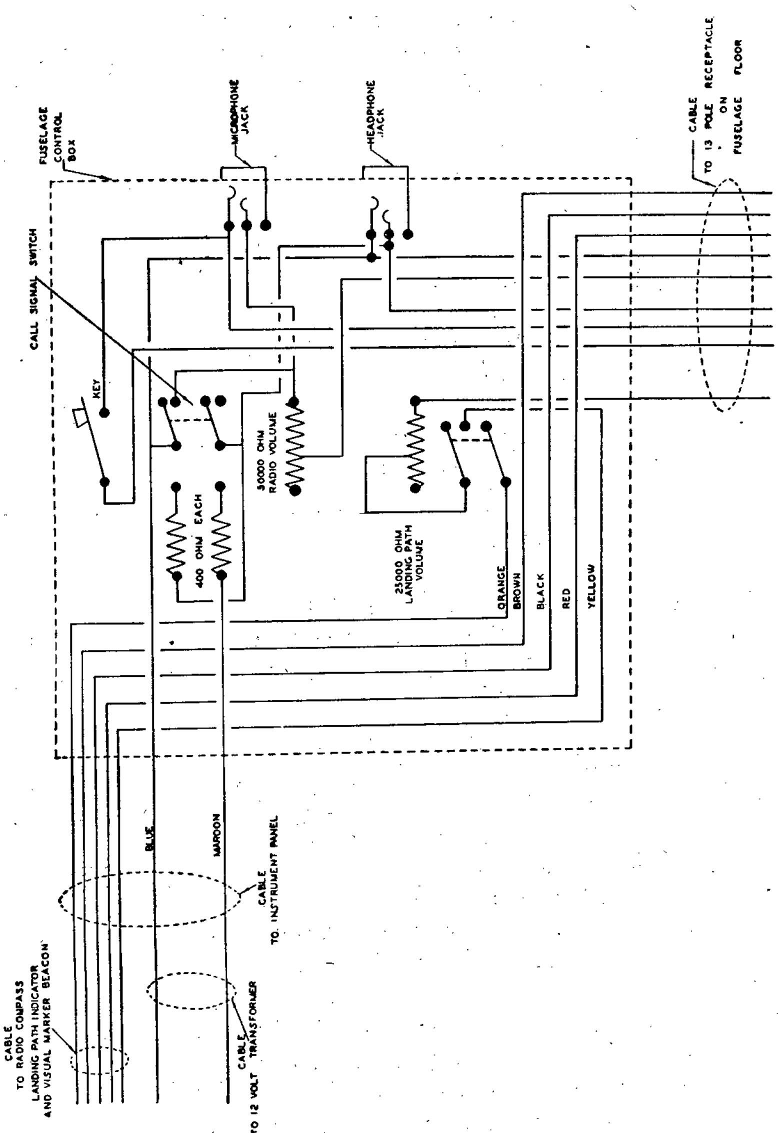


FIGURE 129.—Control box wiring, C-4.

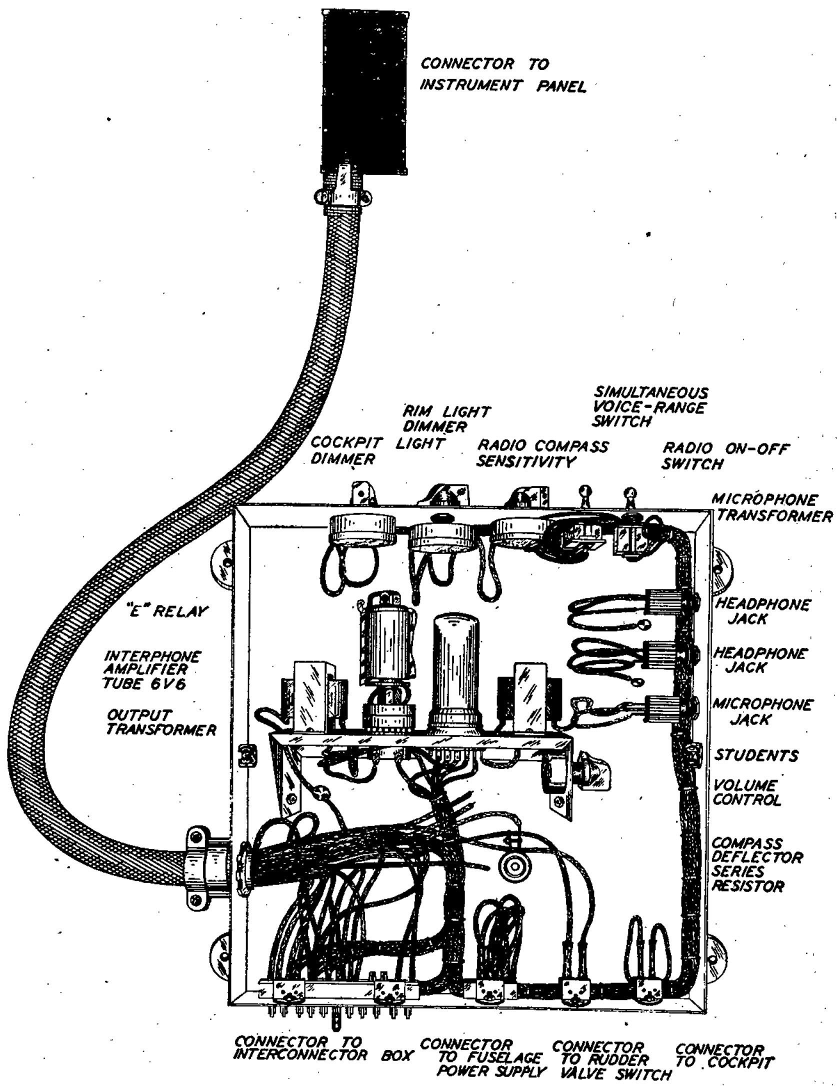


FIGURE 130.—Control box (fuselage C-5).

volume control controls the level of the audio volume out of the student's microphone. Having been set once for a comfortable level of volume for both the student and instructor, it is wise to let them alone. The function of the E relay is to disconnect the radio receiver when either the student's microphone button is pressed or when the interphone radio switch on the control chassis is operated. It serves as well to apply operating voltage to the student's microphone when the microphone button is pressed. The simultaneous voice range reception provides simulated simultaneous voice range reception for radio range problems. Operation of this switch will ground either wire 12 or wire 13 (fig. 131) which will operate the A or B relay in the control chassis, thereby disconnecting either range tone or voice tone applied to the transmitter as modulation. When left in the center or simultaneous position, both the A and B relays at the desk are inoperative giving the effect of simultaneous voice range. The radio compass sensitivity control determines the amount of deflection of the radio compass indicator for a given amount of turn and is controlled by the student in the same manner as the radio compass sensitivity control would be used in aircraft. The dimmer controls, both rim light and cockpit light, serve the purpose of regulating brilliance of the rim light or cockpit lights in the trainer. The azimuth scale illuminating lamp is also controlled by the cockpit light dimmer. The radio on and off switch is provided to turn the radio on and off should it be unnecessary to use a radio receiver for a particular problem. On the side of the fuselage control box are provided three jacks. The bottom jack is provided for the student's microphone. The two upper jacks are for headphones, one for the student's headphones and one for the instructor's headphones should it be desirable for him to come to the trainer to explain a point to the student. Both headphone jacks are wired in parallel. Relation of various component parts is also indicated on figure 130.

d. C-3 control box.—The following controls are provided on the fuselage control box (fig. 132) : radio volume, for controlling the radio signal level in the earphones; station selector, for selecting either range, inner or outer marker stations; radio compass sensitivity; call switch and cockpit light dimmer. Within the control box are also located two transformers which supply current for the fluorescent lights. Two additional transformers are also provided, one supplies current to the marker lamp while the other provides current for the compass deflector as well as the call signal switch. The compass deflector rectifier and adjustable resistor are also located in the fuselage control box as are the headphone and microphone jacks. For internal wiring see figure 133.

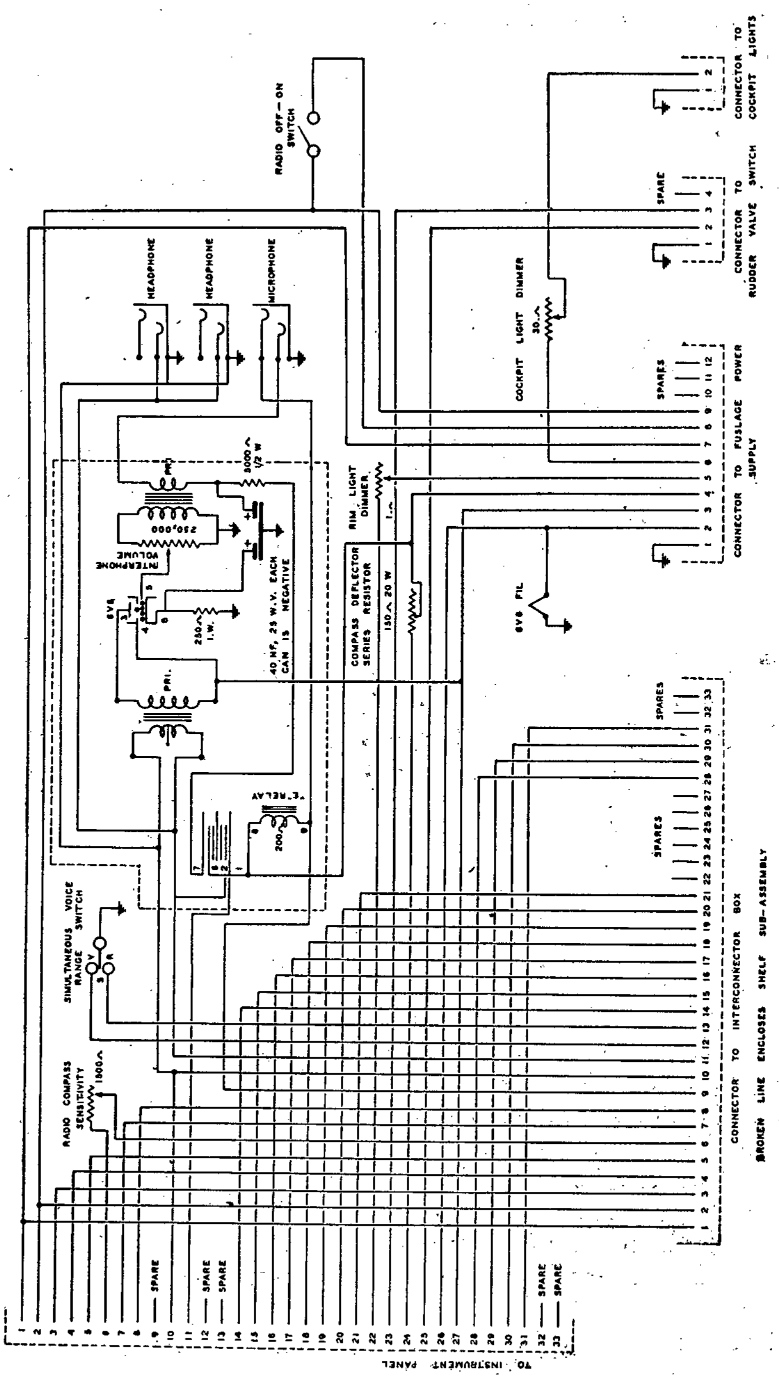


FIGURE 131.—Control box wiring, C-5.

42. Collector ring and brushes.—*a.* Serving as a means of transmitting the various currents and voltages necessary for the operation of the trainer, from the fixed base to the fuselage, is the collector ring and brush assembly (fig. 134).

b. The brush assembly is fixed to the base of the trainer on the bracket that supports the Autosyn pick-up assembly. The contacts consist of two spring brass leaves, overlapping, serving each collector ring in such a manner that they make continuous, positive, contact with the ring they serve.

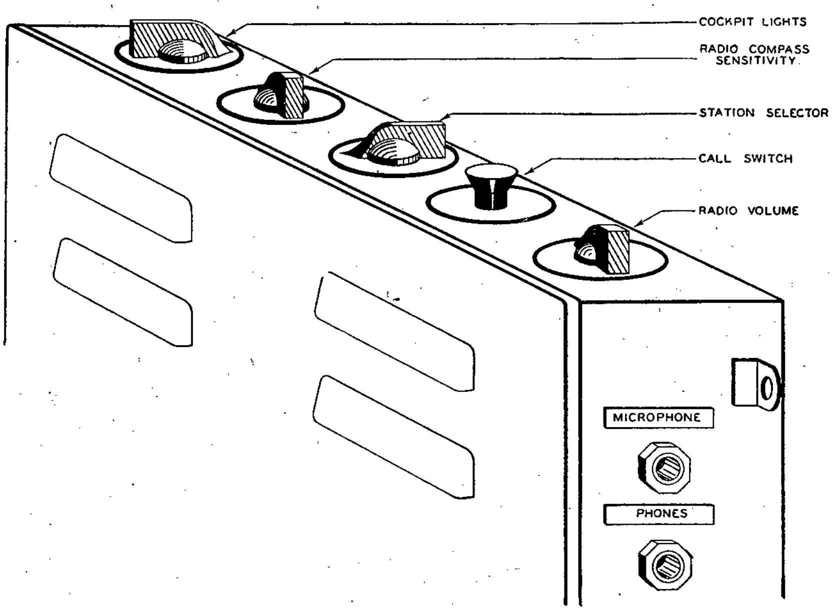


FIGURE 132.—Control box, C–3.

c. The collector ring assembly, on all late model trainers, consists of 21 collector rings, separated from each other by a nonconductor phenolic material, connected internally to the binding posts mounted on top of the assembly, which in turn serve the wiring extending through the spindle into the fuselage.

d. The collector ring brushes should be checked daily to see that they are making positive contact throughout the 360° of trainer movement. The brushes and rings should be cleaned with carbon tetrachloride at the 50-hour inspection period, checking at the same time to see that the brushes are centered on the rings and not shorting across the rings. If the brushes are not centered on the ring they serve, loosen the two screws provided and move the complete assembly

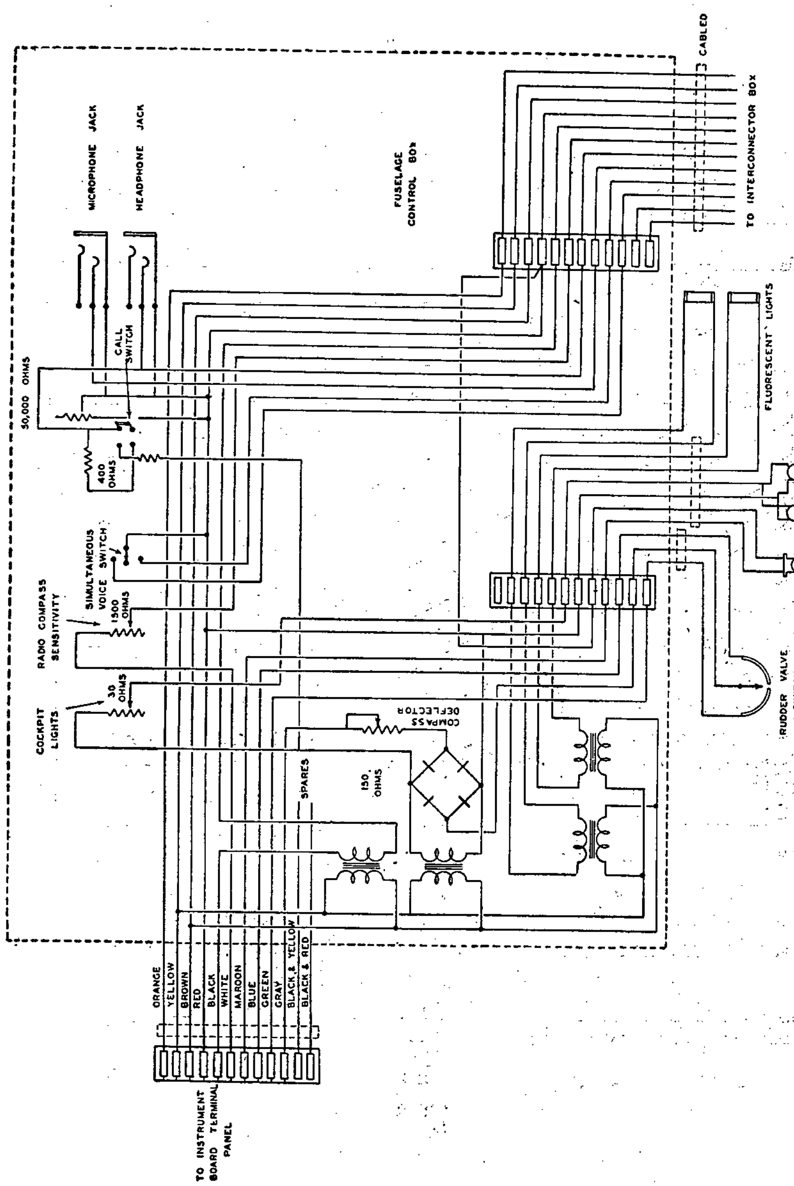


FIGURE 133.—Control box wiring, C-3.

until all spring contacts are centered. If these contacts are not kept clean and in their proper places at all times, noise similar to atmospherics or static will result in the radio simulating circuits, shorts, and consequent erratic indications of the instruments of the Telegon system will result.

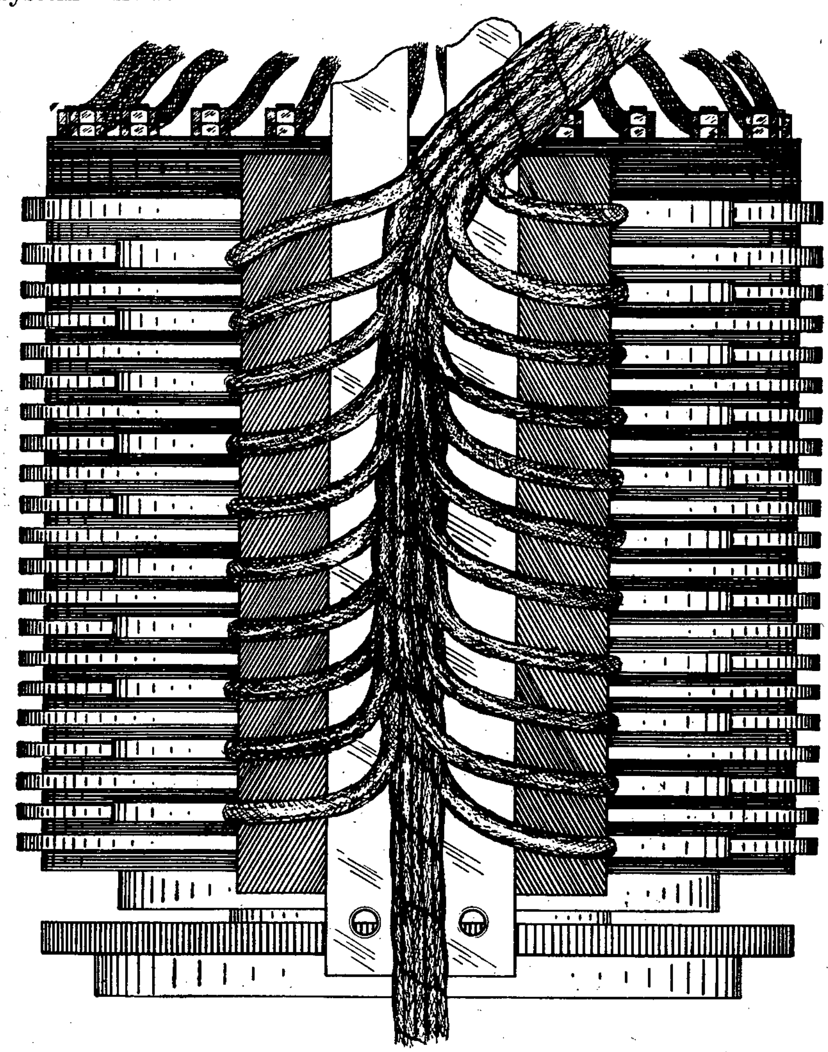


FIGURE 134.—Collector ring and brush assembly.

43. Base terminal box.—This unit, located in the trainer base, serves to house various electrical units, switches, and terminal blocks of the trainer. The various units included vary slightly with the type of trainer they serve. Figure 135 is a drawing of the various units

included on the C-4 model, while figure 136 is a detailed drawing of its internal wiring.

44. Automatic recorder.—*a.* The recorder travels over the map or chart being used on three wheels, two driving the complete assembly and the third leaving an inked track.

b. Directional control is obtained by the use of the Autosyn or, on late models, the Teletorque (Selsyn type) motor, located in the center

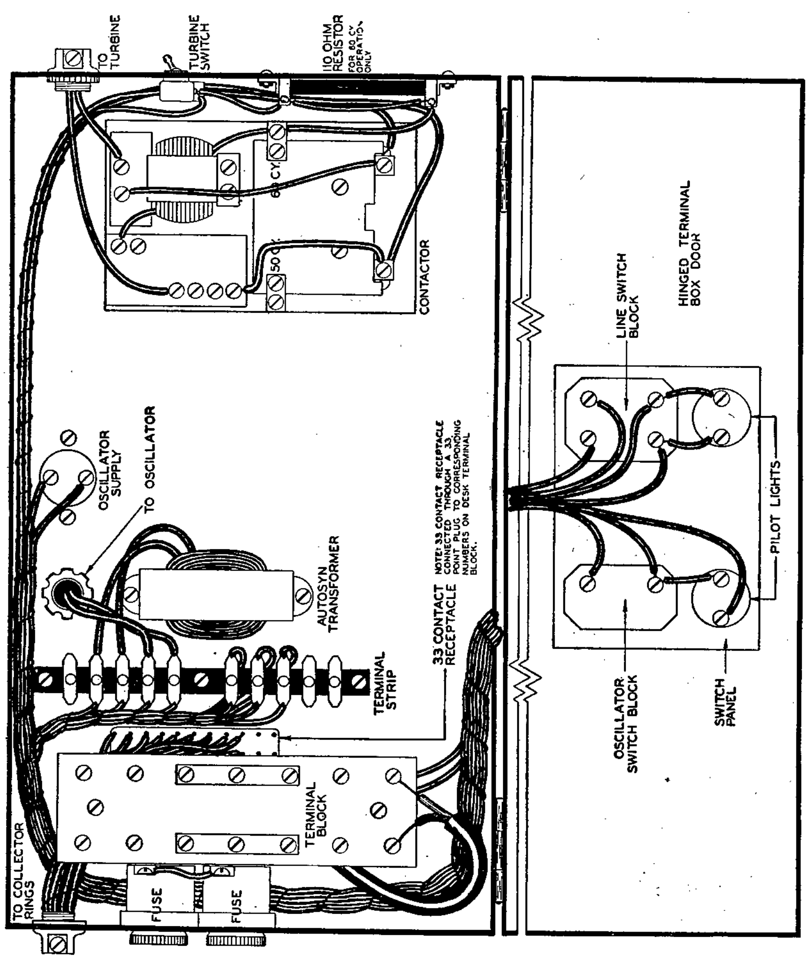


FIGURE 135.—Base terminal box, C-4.

of the recorder (figs. 137 and 138). Each of the three wheels is attached to a vertical shaft on top of which is a large gear. All three of these gears mesh with the small pinion gear on the Autosyn or Teletorque motor. Thus, when the motor is caused to rotate, the three large gears and their shafts also rotate and steer the three

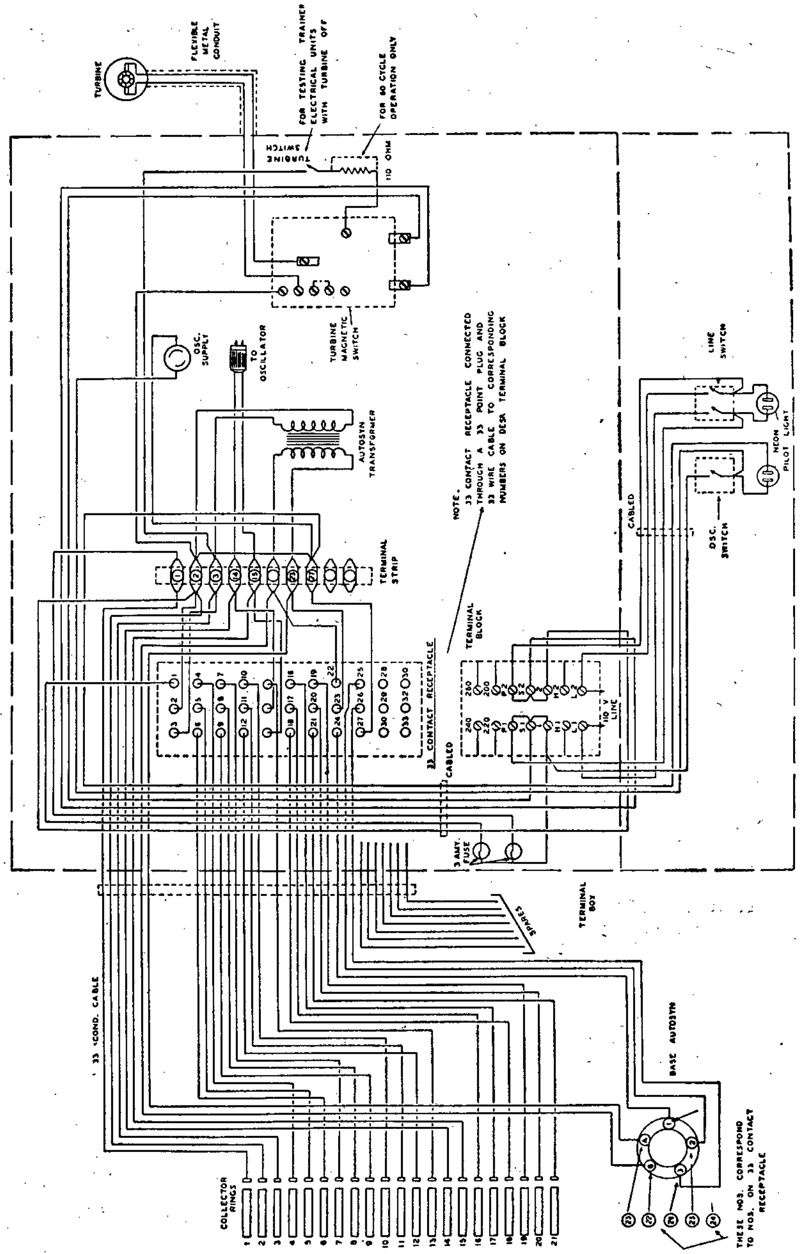


FIGURE 136.—Base terminal box wiring, C-4.

wheels. A similar Autosyn or Teletorque motor is located in the trainer base and geared to the trainer spindle by the gear train of the Autosyn pick-up assembly; and through the wind drift mechanism to the spindle, on trainers equipped with the automatic wind drift device (fig. 120). It is a characteristic of the Teletorque or Autosyn motor that, when the transmitter motor in the base is rotated by trainer movement (turning), the receiver motor at the recorder duplicates the turn, thus steering the drive wheels and inking wheel of the recorder, causing the turns made to be traced on the chart. When the trainer main switch is turned on, the Teletorque motors are energized from the 32-volt transformer that serves them, and "come alive", therefore, lining up with each other. Since the one in the base is geared to the main spindle and cannot move unless the trainer moves, the one on the recorder rotates and lines itself up with the one in the base. However, since the gear ratio between the motor pinion gear and the large gears is 12 to 1, when the recorder directional motor is energized, the recorder will jump to the nearest one of 12 different headings. If the recorder is properly synchronized (*f* below), it will only be necessary, at the start of each problem, to move the large gears around by hand until the inking wheel is headed in the same direction on the chart as the fuselage is headed by compass, shown by the cards on the octagon.

c. Two synchronous Telechron constant speed motors are geared to the driving wheels and provide forward travel of the recorder. These motors operate on 110-volt, 50- or 60-cycle current. On 60-cycle current the armatures of the motors turn 3,600 rpm. This speed is greatly reduced by the brass external driving gears to the desired tracking speed. This enormous gear reduction should make it clear that these motors *must not be turned by hand.* The standard 1 rpm (pinion speed) motor with its associated gear train travels at the rate of 7/8 inch per minute. Various speed motors are furnished, on models previous to the C-5 and C-3 and may be procured if necessary, being 2 rpm, 1 3/4 inches per minute; 4 rpm, 3 1/2 inches per minute. To change motors on the recorder from a high speed set to a low speed pair, or vice versa, simply remove screw (A) (fig. 137) and remove the motor assembly. In mounting a motor, be certain that the squared spindle end fits exactly into the milled slot of the motor mounting plate. If it does not, the recorder will not track properly. For the same reason, be certain that both motors are rated at the same speed.

d. Because of the internal gear train and its lubrication (the motor proper and internal gear train are a sealed unit), low temperatures will cause the motor to run irregularly or slowly and the recorder will not

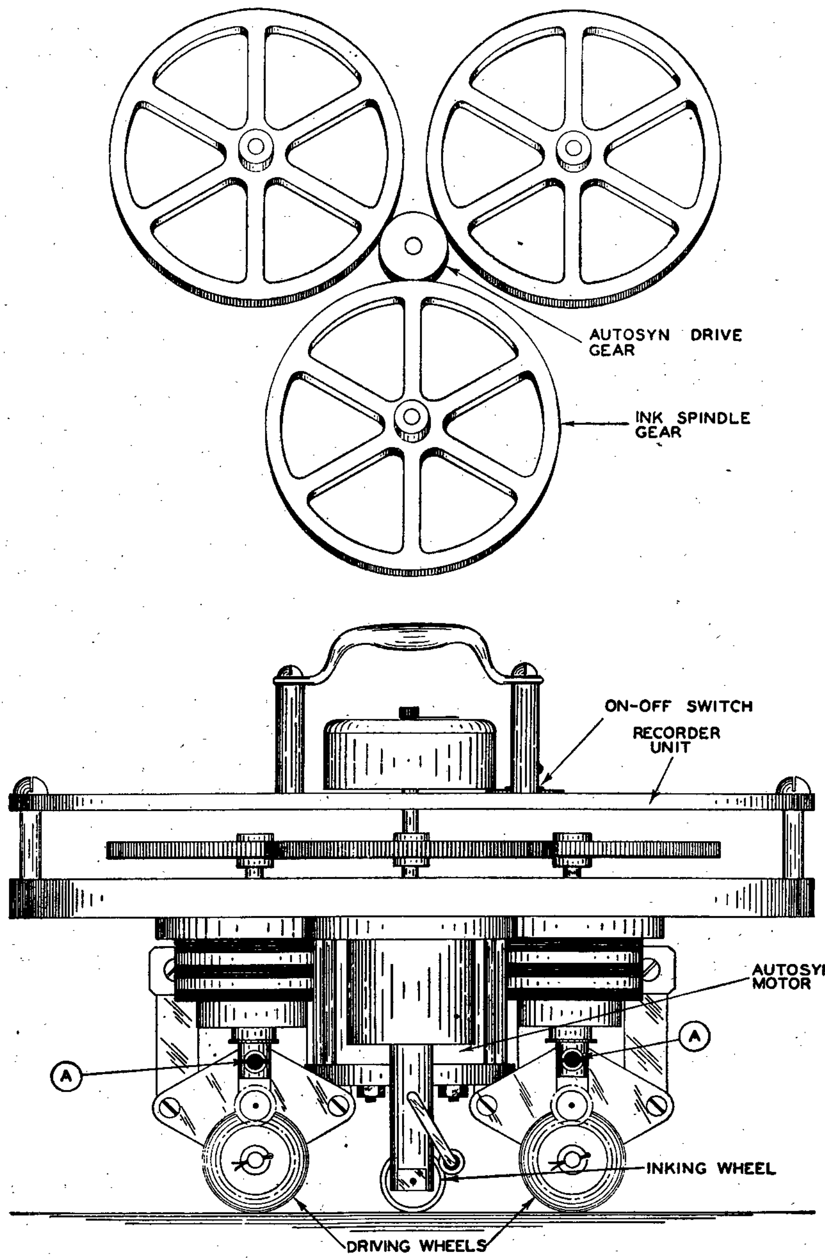


FIGURE 137.—Automatic recorder.

track properly. Current is supplied to the Telechron motors by a pair of fixed slip rings mounted on each shaft housing and spring contact brushes on the motor assembly. Observe the same care and pre-

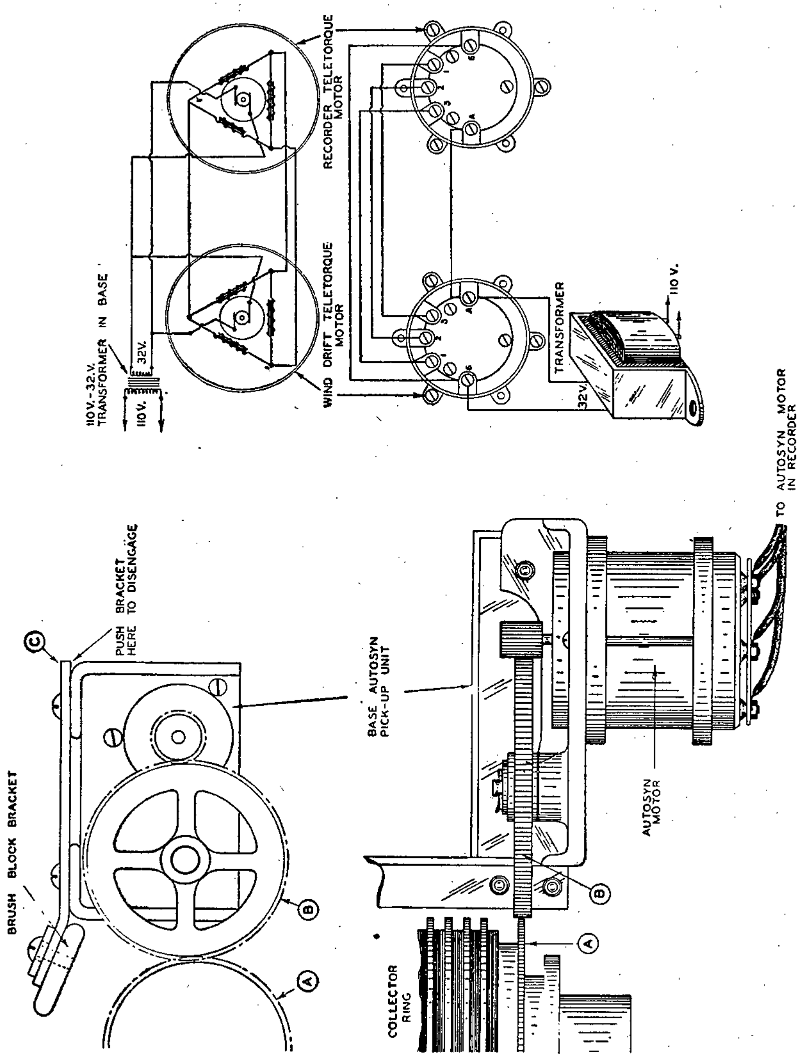


FIGURE 138.—Autosyn or Teletorque circuit.

cautions on these rings and brushes as are stipulated for the main collector rings and brushes.

e. C–3 trainers are provided with a shifting device whereby the external drive gears of the motors can be shifted from a low speed to a high speed (fig. 139). The low speed gears are used for ordinary

instrument and radio problems; while the high speed gear may be utilized for instrument landing problems or such other work as requires great detail in the resulting track. It is possible to change from low speed gearing to high speed without removing the motors from the spindles. To do this, merely shift the large gear (A) (fig. 139) to engage with the smaller driving gears (B). The wheels, when in position (C), drive the recorder at the rate of .845 inch per minute at cruising speed, no wind. To change the speed of the recorder,

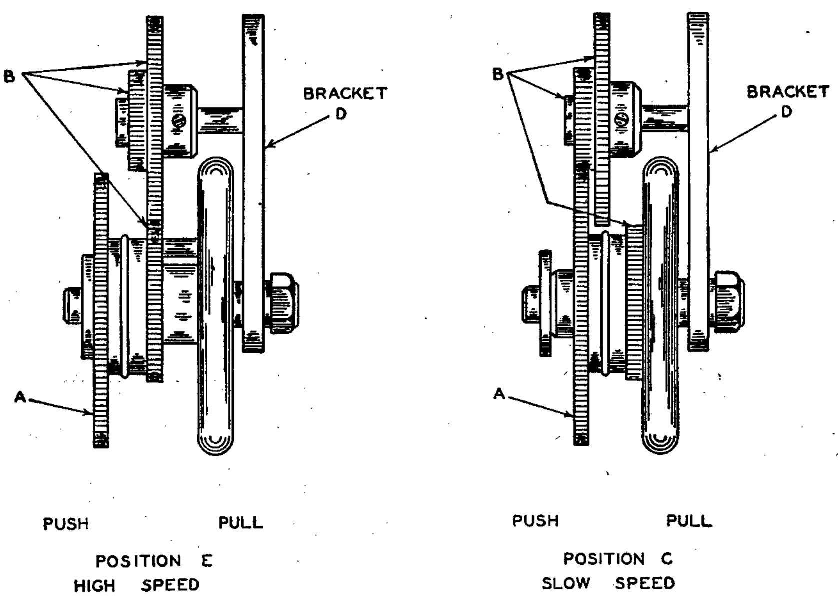


FIGURE 139.—Telechron motor gear shift.

shift the gear by pulling the large driving gear away from bracket (D) to engage the other set of small driving gears. With the gear as shown in position (E), the recorder travels at the rate of 3.38 inches per minute at cruising speed, no wind. When shifting gears, make sure that both gears are engaged, as there is a neutral position between each gear ratio. Be sure also that both motors are set to the same tracking speed.

f. Adjustment.—The initial adjustment is necessary to aline the direction of travel of the recorder to agree with the direction of travel of the trainer. To synchronize the recorder, unplug or switch off the vacuum turbine in the base, and turn the trainer main switch on. Then turn the trainer by hand to see that the recorder turns in the same direction as the trainer. If it turns in the opposite direction, reverse

the leads 1 and 2 on the Autosyn motor of the recorder. Head the trainer exactly north. Rotate the movable dial that has a compass rose graduated on it (0 to 360) until the 0 of this scale is opposite the fixed reference pointer (A) (fig. 140). By means of the three large gears in the recorder, turn the inking wheel until the movable pointer (B) is over the 0 on the movable dial (C) and in line with the

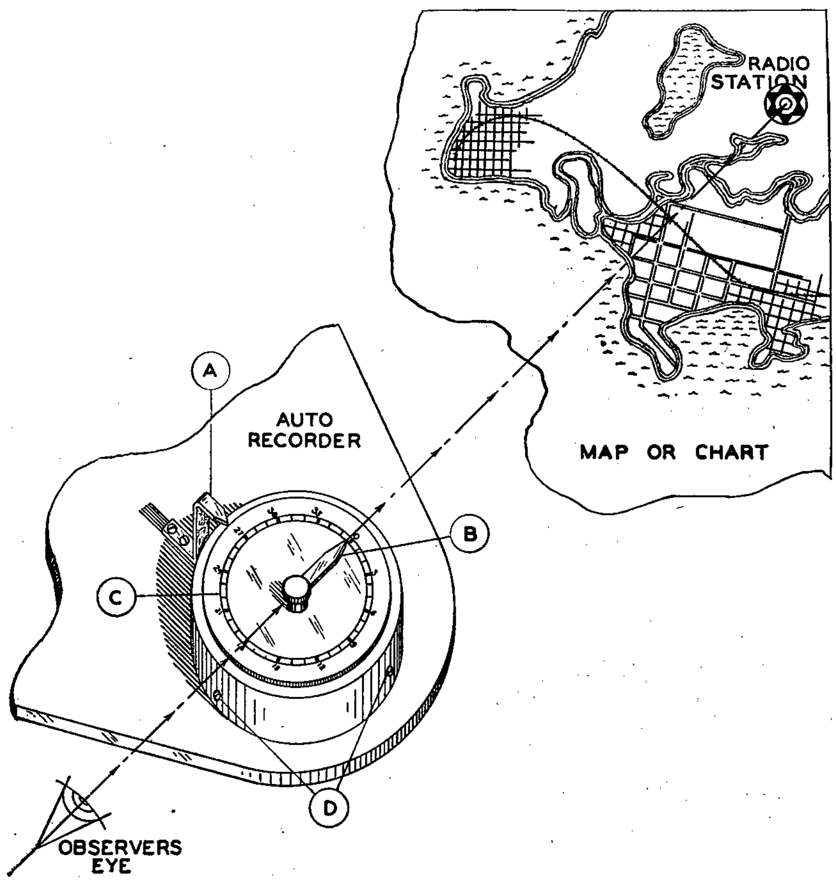


FIGURE 140.—Auto recorder radio compass control.

fixed reference pointer (A). Let go of the large gears. If the pointer moves away from the 0 it is necessary to correct this in the base of the trainer. To do this, on models previous to the C-5, spring out bracket (C) (fig. 138) enough so that gears (A) and (B) will just clear each other. While holding the bracket, have a helper rotate the large recorder gears. This will turn one of the two gears in the

base. When the pointer is on 0, allow the gears to mesh as directed in paragraph 40*k*.

g. The recorder should be checked and tested every 50 hours, or whenever a need is indicated for alinement and proper tracking. To check the alinement of the driving wheels, place a straightedge against them as shown in figure 141. Both wheels should be flat

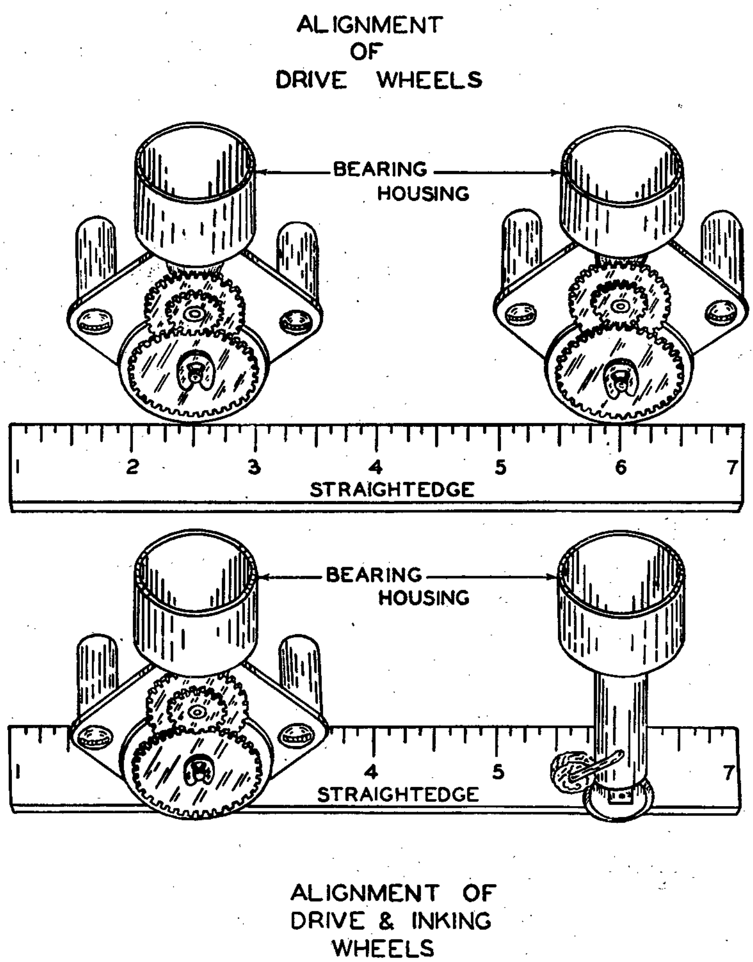


FIGURE 141.—Alinement of recorder wheels.

against the straightedge. If they are not, loosen the set screws in one of the three large gears which are mounted on the vertical shaft, turn the shaft so both wheels are flat against the straightedge and tighten the setscrews. To aline the inking wheel, place the straightedge against one of the drive wheels and the inking wheel (fig. 141).

Use the side of the driving wheel which is away from the driving gear. Again, the two wheels should be flat against the straightedge. While this latter alinement is not mathematically exact, due to the difference in thickness of the drive wheel and inking wheel, it is sufficiently accurate for practical purposes. The pointer (B) (fig. 140) must be exactly in line with the inking wheel. Place the straightedge tightly against the two driving wheels. Set the pointer so it is exactly on 90° (or 270°) and pointed in the direction the inking wheel travels. When the recorder is being placed in service, it is necessary to connect it into the electrical system by means of the cord and plug provided. When making this connection *lift the recorder from the table and insert the plug;* never push the plug into place while the recorder is being supported by the drive and inking wheels. If the recorder is pushed hard against the desk, banged against the desk edge or otherwise roughly handled, the driving wheels will be sprung out of line. If this occurs, the recorder will draw nonparallel lines on reciprocal headings and circles of unequal diameter in opposite directions. This is caused by displacing the driving wheels from their proper positions, with their point of contact with the map exactly under the center of the vertical spindle.

h. Test track (fig. 142).—Head the trainer north and line up the side of the octagon with the base as when compensating the compass. Turn on trainer main switch. (Turbine should not be running.) Turn on the recorder and let it run for 5 or 6 minutes. Then grasp the end of a wing and walk the trainer around exactly 180°, using the base as a reference. Allow it to run for another 5 minutes, then turn back to the previous heading, walking the wing around as before. All three tracks should be parallel within $\frac{1}{32}$ inch in 6 inches, and the same distance apart within $\frac{1}{32}$ inch. In making this test, do not attempt to fly the trainer around the turns, or to do it by the turn indicator. Errors in the indicator and inaccuracy of execution would make the results undependable. The rate at which these turns are made is not especially important. It is important that the rate be the same in both directions. This can be done quite accurately by stepping the wing around heel to toe, timing the steps with a stop watch at, for example, one step per second. If the test track is not within limits, another one or two tracks should be run to make sure the fault is with the recorder and not the operator. If the two outside lines are parallel but the middle one is not, one of the driving wheels is not centered. If the lines are parallel but not equally spaced apart, both wheels are off center. Figure 142 shows the four possibilities. In "A", the right-hand drive wheel should be moved,

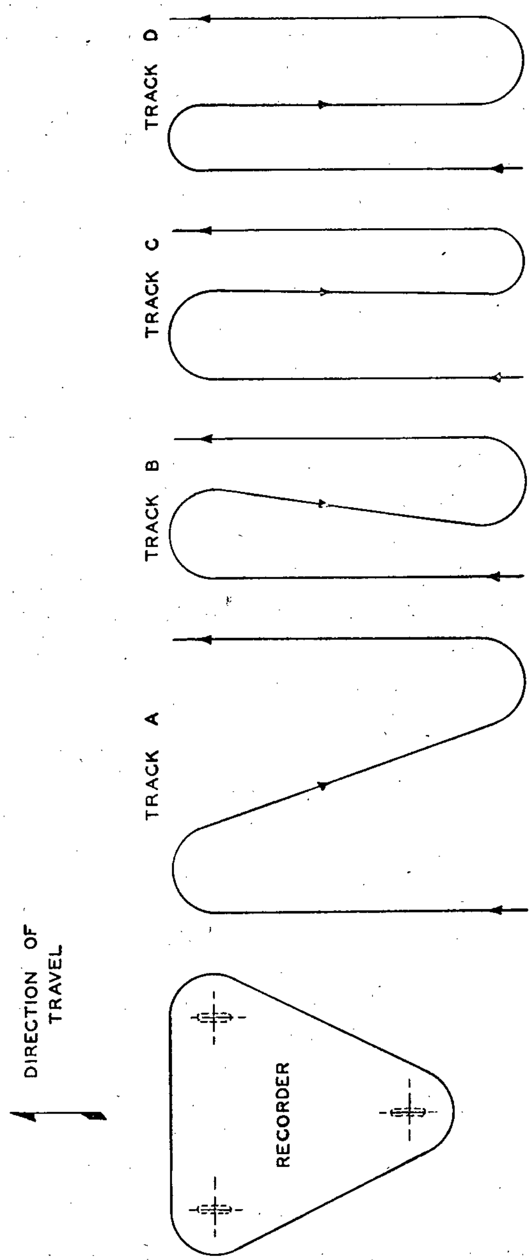


FIGURE 142.—Recorder test track.

by shimming, slightly toward the motor; in condition "B", the same wheel is moved slightly away from the motor. In "C", both wheels should be moved slightly away from the motors; in "D", both slightly toward the motors.

45. Radio compass.—*a.* This instrument on the trainer is not controlled by radio but is designed merely to simulate the radio compass for the trainer. The indicating instrument is a voltmeter which indicates with right or left movements of the pointer according to the polarity (+ or —) of the current. The current to operate the radio compass is rectified a-c, of 10 volts, obtained from a secondary winding of the power transformer in the desk power supply on C–5 and C–3 trainers, and from two banks of three each dry cells in the trainer desk on earlier models. The control unit is on top of the automatic recorder (fig. 140). This consists of two resistance units and a movable contact which moves as the trainer heading is changed. The wiring is connected in such a manner (fig. 143) that, when the movable contact is exactly in the center of one of the resistance units, no current flows. The moment a slight turn is made to the right or left, current flows proportionately positive (+) or negative (—) to the meter causing an indication to register to right or left. The resistance unit is actually two units set 180° apart so that the same action takes place when headed in the opposite direction, except that the needle of the indicator swings in the opposite direction the same as in the actual radio compass in flight.

b. Adjustment.—There are three adjustments on the radio compass: centering of the indicator pointer by adjusting the small screw located on the face (fig. 105); the headings on which the needle will center without moving the dial must be exactly 180° apart; the right-left indicator must be centered when the movable pointer (B) (fig. 140) is over the zero on the rotating dial. If necessary to make these adjustments, before adjusting the radio compass control unit, check for centered pointer of the indicator with the current off. Turn on the main switch in the trainer, so the record teletorque will be "alive". If the pointer is not centered, remove pointer (B). Remove three small screws (D), (fig. 140) and lift off movable cover. Turn the trainer by hand until, with full volume on, the L–R indicator needle is exactly centered, with the wiping brush (A), (fig. 144) in contact with the lower of the two resistor disks (B). Then, being careful not to disturb the trainer, rotate the large recorder gears through six "electric notches". Now, loosen the large nut (C) that holds the two disks, and rotate the top disk (D) slightly one way or the other (being careful not to disturb the lower disk) until the L–R needle is again exactly centered. Tighten the nut and recheck on both headings, then replace the

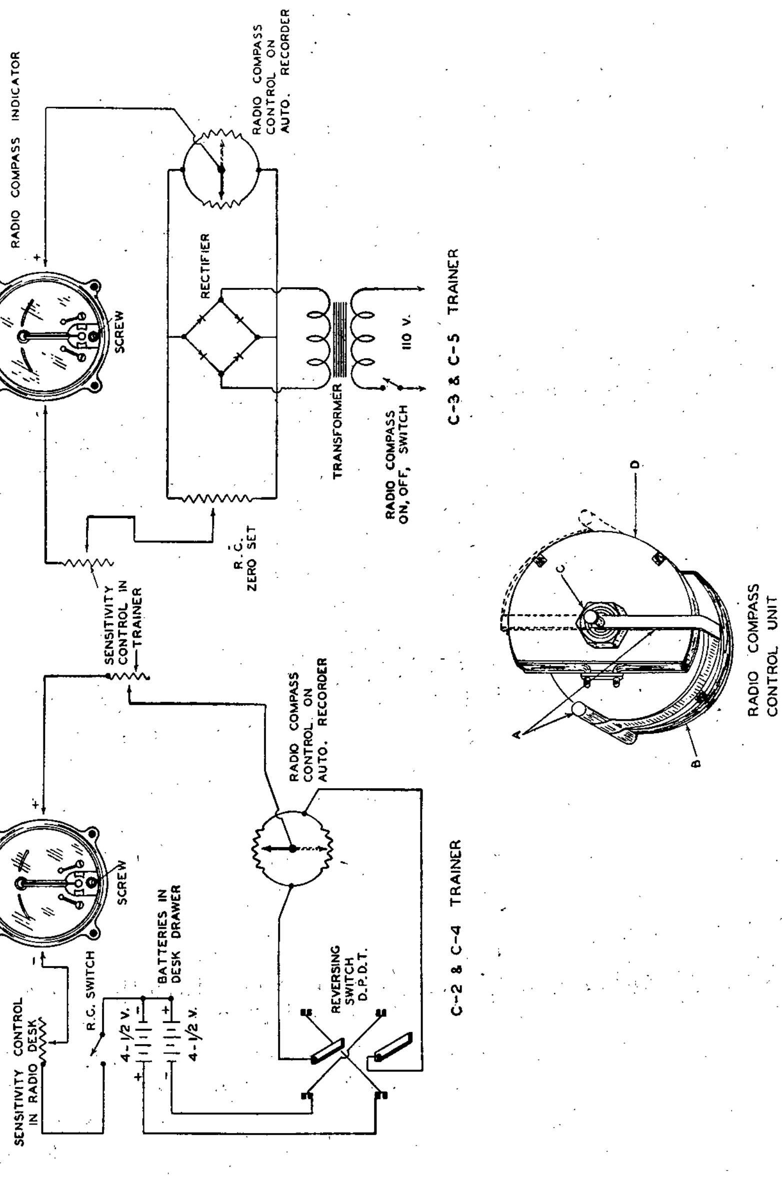


FIGURE 143.—Radio compass wiring diagram.

dial and pointer. To obtain the second adjustment, leave the trainer main switch on and make sure the pointer is pointed in exactly the same direction as the inking wheel. Next, rotate the dial until the zero is exactly under the pointer. Now, *being very careful not to disturb either the rotatable dial or the trainer*, remove the pointer and the three screws that hold the cover in place and carefully lift off the cover. Loosen the small special nut that holds brush (A) meanwhile holding the large recorder gear from turning. Move the brush until the L-R

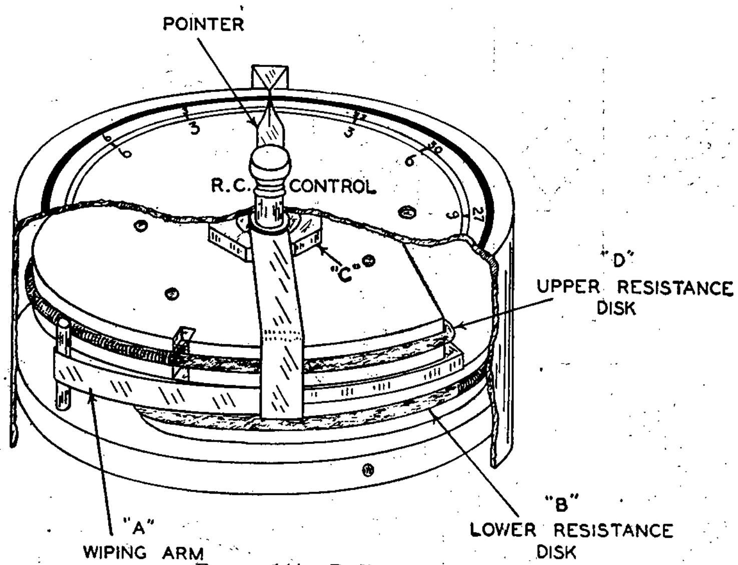


FIGURE 144.—Radio compass control.

needle is exactly centered and tighten down the special nut. Replace the dial, with the zero pointed in the same direction as the inking wheel, and replace the pointer exactly over zero.

46. Radio simulating equipment.—*a. General.*—The C–2 radio simulating equipment consists of the radio chassis, the range keyer assembly, headsets, microphones, terminal blocks, junction boxes, and various interconnecting cords and plugs. The purpose of the radio simulating equipment is to simulate radio ranges, marker beacons, and aircraft radio transmitters and receivers. It makes it possible for the student to "fly-the-beam", use the marker beacon, and have two-way voice or two-way code communication with the instructor who is acting as the ground station radio operator. The radio chassis contains the various vacuum tubes, transformers, condensers, resistors, controls and switches, and wiring that makes up the different circuits used. The complete radio circuit may be divided into four more or less separate

components: rectifier circuit, amplifier circuit, course beam oscillator (also used for code transmission), and marker beacon oscillator.

(1) *Rectifier circuit.*—The rectifier is of the conventional type, full-wave rectifier, using a standard 80, high-vacuum tube. The purpose of this circuit is to provide the necessary direct current voltages for the other circuits.

(2) *Amplifier circuit.*—Two 37 tubes are used as amplifiers for course beam, as well as phone and code signals. By means of a three-circuit switch, the necessary circuits are shifted to provide the proper circuit for the function intended. This switch is called the circuit selector switch. The purpose of the amplifier circuit is to amplify or build-up, or make louder the various signals that are fed through it.

(3) *Course beam oscillator.*—A 37 tube is used in the oscillator circuit, which is of coventional design. The purpose of the course beam oscillator circuit is to provide a steady audible tone or hum which is used either to send code or send range signals.

(4) *Marker beacon oscillator.*—This circuit is identical to the course beam oscillator in design and construction. Its purpose is to provide a steady audible tone, or hum, which is used in sending marker beacon signals.

b. Controls.—Different types of trainers have different types of controls on the radio chassis. The C-2 type trainer uses the basic circuits of all trainers, and has the basic controls on the radio chassis. Figure 145 shows the complete radio chassis with each control and part labeled.

c. Radio range keyer.—This device automatically produces A-N, E-T, marker beacon and station identification signals. In most trainers, the main cam assembly with its several sets of call letters may be replaced in a few seconds with an assembly giving an entirely different set of call letters. The gearing of the cam shaft is selected according to the type of current specified with purchase. If it is desired to change the type of current for any reason, such as from 60-cycle to 50-cycle, it is necessary to replace the cam shaft with one of the proper gear specifications. The motor is a constant speed type and requires no adjustment as long as it is operating on the proper current.

d. Volume control in cockpit.—The cockpit volume control in the trainer is effective only on radio beam practice. A separate wire is brought from this control into the radio chassis and connected to a switch which is closed only when the beam phone code switch (fig. 145) is set for beam. This is done so that the instructor may cut in and talk to the student at normal voice level, regardless of what the student does with his volume control.

e. Beam compensator.—This unit serves to compensate for any unbalance in the A and N amplifier tubes, or in the resistance of the beam shift control. In effect, it is a small auxiliary beam shift control. When a zero position of the beam shift does not produce a solid on-course signal, the condition can be corrected with a small adjustment of the compensator.

f. Radio beam, voice or code, on the C-4 trainer may be selected by means of circuit selector switch (A) (fig. 146). Control of voice or code volume is obtained with volume control (B); radio volume with control (C); marker beacon signals are selected with switch (D), their volume controlled with (E). Distance from station (visual indicator sensitivity) is governed with (F). The toggle switch (G), in the left corner turns off the radio keyer when it is not needed during primary instrument flying instruction. Choice of radio range signals or landing beam is obtained with the five-position switch located in right rear of main radio chassis. In the left-hand—number 1—position, the E-T or landing beam system is operating. In the other four positions of this switch, radio range signals are produced—the four positions providing four different station identification calls. Radio range signals (A's, N's, and on-course) are produced with control (I). With this control in the center (at 0) a solid on-course (steady tone) signal should be heard. If, with this control centered, a faint A or N can be heard, the compensator should be turned one way or the other until a clean on-course is heard in the earphones. Switch (K) causes the inner, high-pitched marker to produce either a steady continuous note or a keyed signal. Switch (L) is the main on-off switch for the radio chassis. A multiple outlet is provided on the back of the desk for plugging in several pairs of headphones. The microphone plugs directly into the radio chassis. The microphone switch must be on when talking into it. ***Warning:*** These microphones are very sensitive and *must not be handled roughly.* To do so will dislodge the carbon granules or otherwise damage the instrument.

g. Following is a description of the combination radio beam, marker beacon, two-way phone and two-way code device for the C-4 trainer. The circuit may be divided into four more or less separate components: rectifier circuit, amplifier circuit, course beam oscillator (also used for code transmission), and marker beacon oscillator.

(1) *Rectifier circuit.*—The rectifier is composed of the following units (fig. 147): transformer T-1 having a primary winding and three secondary windings—a rectifier filament winding, rectifier plate winding, and a filament supply winding for the amplifier and the

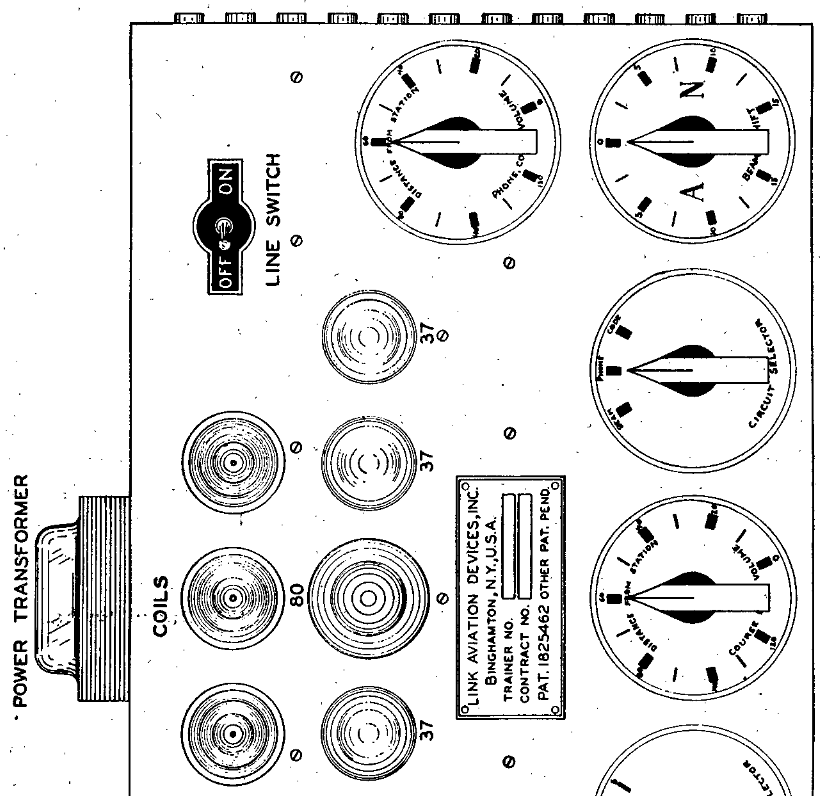


FIGURE 145.—Radio control chassis, C-2.

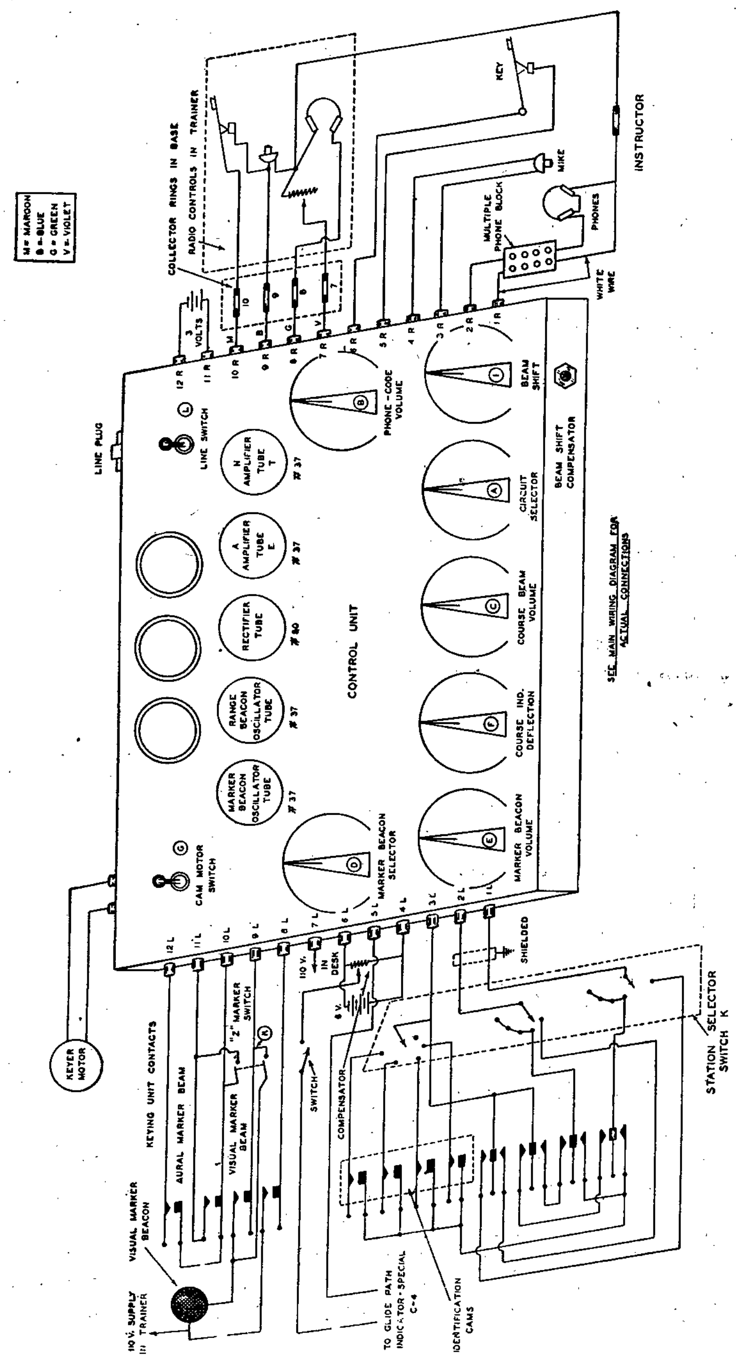


FIGURE 146.—Radio control unit, external wiring diagram.

oscillator tubes. The rectifier tube is the standard 80, high vacuum, full-wave rectifier tube which feeds the rectified current through a filter system composed of chokes L–1 and L–2 and condensers C–1 and C–2 into the voltage divider R–1. The full rectifier voltage (approximately 250 volts) is used for the two oscillators while the amplifier tubes operate on approximately 180 volts obtained by means of a tap on voltage divider R–1. An additional filter condenser C–3 is connected between the 180-volt tap of resistance R–1 and the ground.

(2) *Amplifier circuit.*—Two 37-tubes are used as amplifiers for the course beam as well as phone and code signals. By means of a three-circuit switch S–2 the necessary circuits are shifted to provide the proper circuit for the function intended. Two sections of switch S–2 are in the grid circuits of the two amplifier tubes. When switch S–2 is in position 1 (course beam signals) each grid is separately connected to the two sliders of beam shift control R–4. The A and N (or E–T) signals are fed to the beam shift control R–4 through the cam units. When the two sections of switch S–2 mentioned above are in position 2 or 3, grids of the two amplifier tubes are connected together to the movable contact of phone and code volume control R–3. The third section of switch S–2 is connected in the primary winding of transformeer T–2, which provides connection to the microphones in position 2 and to the code keys in position 3. In the cathode circuits of the two amplifier tubes is a resistance R–10 shunted by condenser C–6. This circuit provides the necessary C–bias (13.5-volts) for the amplifier tubes. The plates of the two amplifier tubes are connected through the primary of the output transformer T–6. The other end of the primary winding is connected to the 180-volt tap on the rectifier.

(3) *Course beam oscillator.*—A 37-tube is used for the oscillator. The plate circuit is connected to one winding of oscillation transformer T–4 and the grid is connected to the other winding. The other end of the plate winding is connected to the 250-volt point of resistance R–1. Condenser C–4 is shunted across the grid winding of transformer T–4 to complete the oscillator circuit. The two windings of the transformer T–4 must be connected to the tube in the proper phase relation in order to obtain oscillation. The output of this oscillator is fed to the beam volume control R–2, the slider of which is connected through condenser C–42 and the two remaining sections of switch S–3 to the cam unit contacts. The oscillator also feeds the code transformer T–3 through condenser C–8. The primary of this transformer is shunted by means of resistance R–9 to

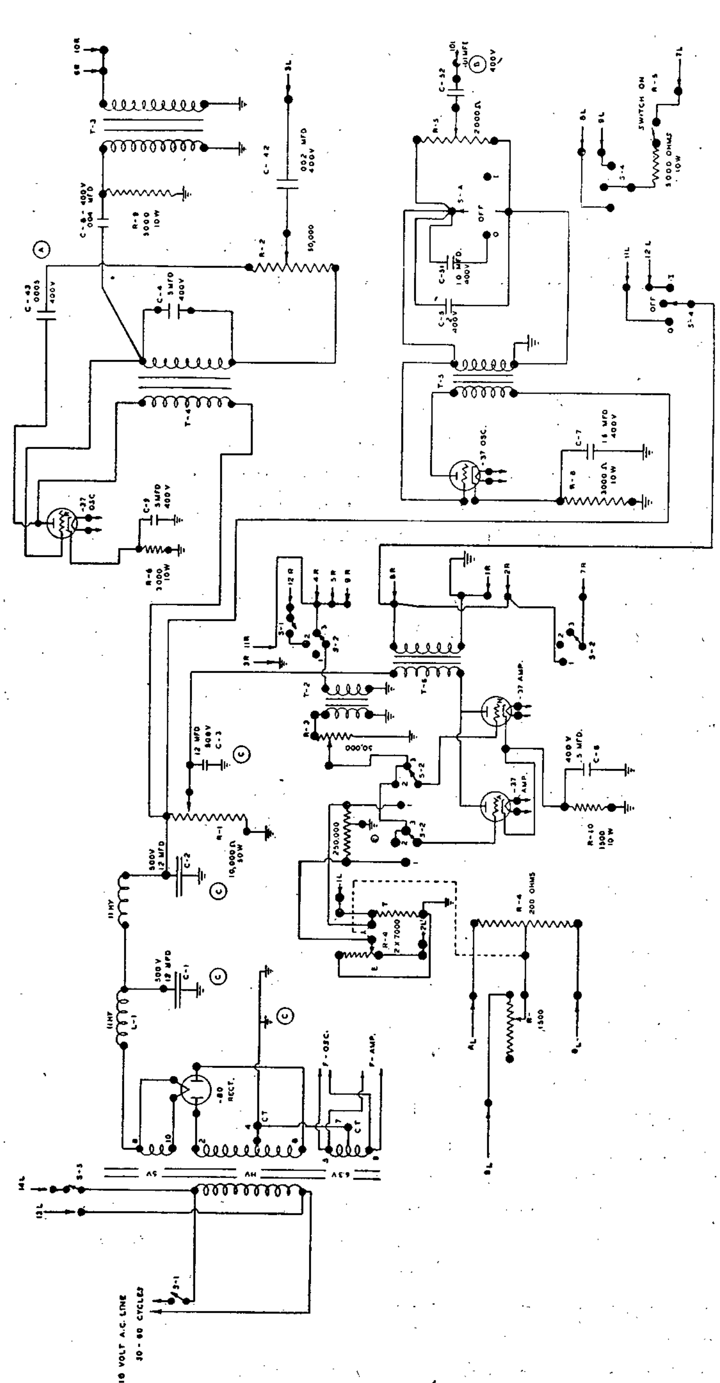


FIGURE 147.—Radio internal wiring diagram.

provide control of the maximum volume obtainable from this transformer. The proper C–bias is obtained by connecting the cathode to ground through resistance R–6 shunted by condenser C–9.

(4) *Marker beacon oscillator.*—(*a*) This circuit is self-explanatory by comparing it to the course beam oscillator circuit. After going through the keying unit contacts, the output of this oscillator is fed into the secondary of the output transformer and not through the grid circuit of the amplifier tubes. The cam circuits as well as the code key, microphone, and phone circuits are comparatively simple and may be traced on the diagrams.

(5) *Cockpit volume control.*—This control in the trainer is effective only on radio beam practice. A separate wire is brought from this control into the radio chassis and connected to a switch which is closed only when the beam-phone-code switch is set for beam. This is done so that the instructor may cut in and talk to the student at normal voice level regardless of what the student does with his volume control.

(6) *Beam compensator.*—This unit serves to compensate for any unbalance in the A and N amplifier tubes or in the resistances of the beam shift control. In effect, it is a small auxiliary beam shift control. When a zero position of the beam shift does not produce a solid on-course signal, the condition can be corrected with a small adjustment of the compensator. The unit consists of a volume control with leads from the ends of the resistor element connected to the grid circuits of the A and N amplifier tubes and the center arm (movable brush) grounded.

h. The radio chassis for C–3 trainers is conveniently located in the center drawer of the radio desk. Mounted on the radio chassis are various controls with which the instructor simulates various radio aids to navigation. Radio range signals are simulated by use of the beam shift control (A) (fig. 148), and choice of five different stations is possible through selector switch (B). Simultaneous range and "voice" or voice only is made possible by means of selector switch (C), while control of voice and range signal strength is accomplished by volume control (D). Visual marker signals are accomplished by automatic relay control (Q) set to actuate the relay keying device when instrument landing control (E) reaches a certain point on the dial. By pushing button (G), coded visual signals are made continuous, thereby affording universal control of visual circuit. Toggle switch (F) turns on the visual marker circuit while (H) controls the aural circuit. Z and fan type markers are selected at switch (I) and controlled by volume control (J). Instrument

landing switch (K) and radio compass (M) control the circuits. Sensitivity of the radio compass is obtained by volume control (L). The radio range and compass circuits are balanced by compensators (O) for the radio compass and (P) for radio range. The code keying device may be turned off at (N) during primary instruction or when it is not needed. The master switch (R) controls the entire unit on or off.

i. Basically the radio equipment of the C–3 trainer is similar to that employed in earlier types of trainers such as the C–2 and C–4.

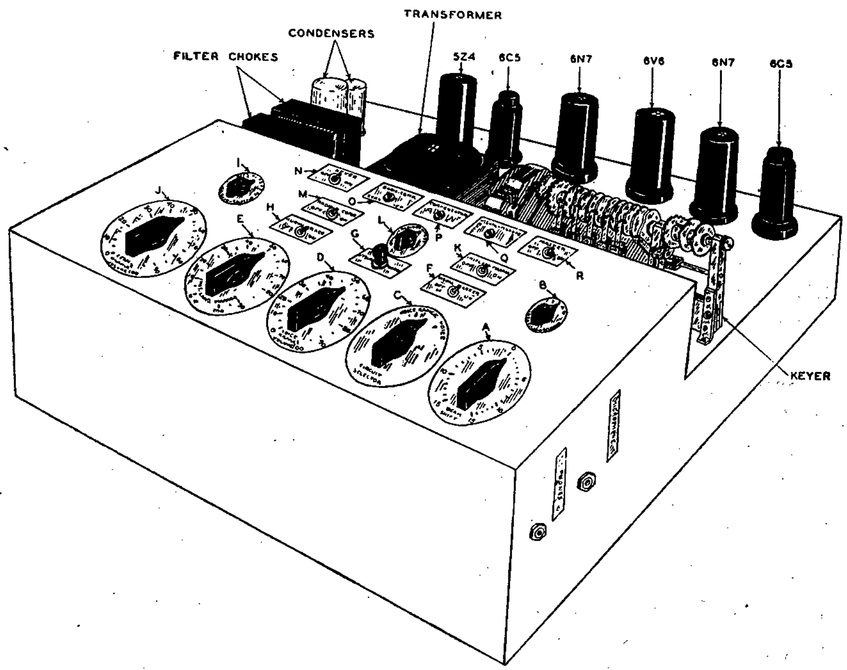


FIGURE 148.—Radio control chassis, C–3.

There is no actual radio transmission employed. Instead, all signals are conducted from the desk to the trainer over wire circuits. The several audio tones are produced within the control chassis, and, after being suitably keyed and intermixed, are amplified and applied to the instructor's and student's headphones. Controls are provided for the selection and control of the various circuits within the control chassis so that range, marker, voice and instrument landing signals may be reproduced to simulate those received in flight. In addition to the aural signals, there are also visual marker signals available. In the cockpit, the student is provided with controls for

station selection, radio volume, signaling, and the usual control switches for trainer operation.

(1) *Radio control chassis.*—(*a*) The circuits of the control chassis (fig. 149) may best be described by separating them according to their function. The power supply section provides the necessary operating voltages for the remainder of the control chassis, the radio compass, the microphone supply and several relays. The power supply section is composed of the following units: a transformer T-3, having a primary and five secondary windings—a rectifier filament winding, rectifier plate winding, filament supply winding, mike supply winding and radio compass supply winding. The rectifier tube is a type 5Z4, high vacuum, full wave rectifier which feeds rectified current through a filter system composed of chokes L-1 and L-2 and capacitors C18, C19, and C20. A bleeder resistor R-24 is provided across the output of the power supply section. A-c voltage from the microphone supply winding is applied to a dry disk rectifier D-1. The output current is filtered by capacitor C21, a portion of the current operating relays RY-1 and RY-2. The remaining current is further filtered by L-3 and C-16 and applied to the microphone circuit. A-c voltage from the radio compass supply winding is applied to dry disk rectifier D-2. In this instance, no filter is employed, the current being applied to the radio compass circuit directly.

(*b*) The range oscillator utilizes a type 6C5 tube in conjunction with an oscillation transformer T-2. Capacitor C11 connected across the primary winding forms the resonant circuit, tuning the oscillator circuit to a frequency of 1020 cycles. The oscillator output signal, after going through the contacts of relays RY-1 and RY-2, is applied to a voltage divider network consisting of resistor R-15 and R-16. The signal thence travels from the function of the two resistors to the range keyer to be keyed as described under keyer operation. The relays RY-1 and RY-2 are controlled by a selector switch in the fuselage control box. With the switch in the range position, neither relay is operated and the signal follows the path described above. With the selector switch in the outer position, relay RY-1 is operated and the additional capacity of C-12 is connected across the resonant circuit resulting in a frequency of 800 cycles. Additional contacts on relay RY-1 serve to remove the signal from the voltage divider network and apply it through switch S-3 to volume control R-12 and eventually to the grid of the 6V6 amplifier tube. This signal then serves to simulate the outer marker beacon signal of the Army Air Forces instrument landing system. With the selector switch in

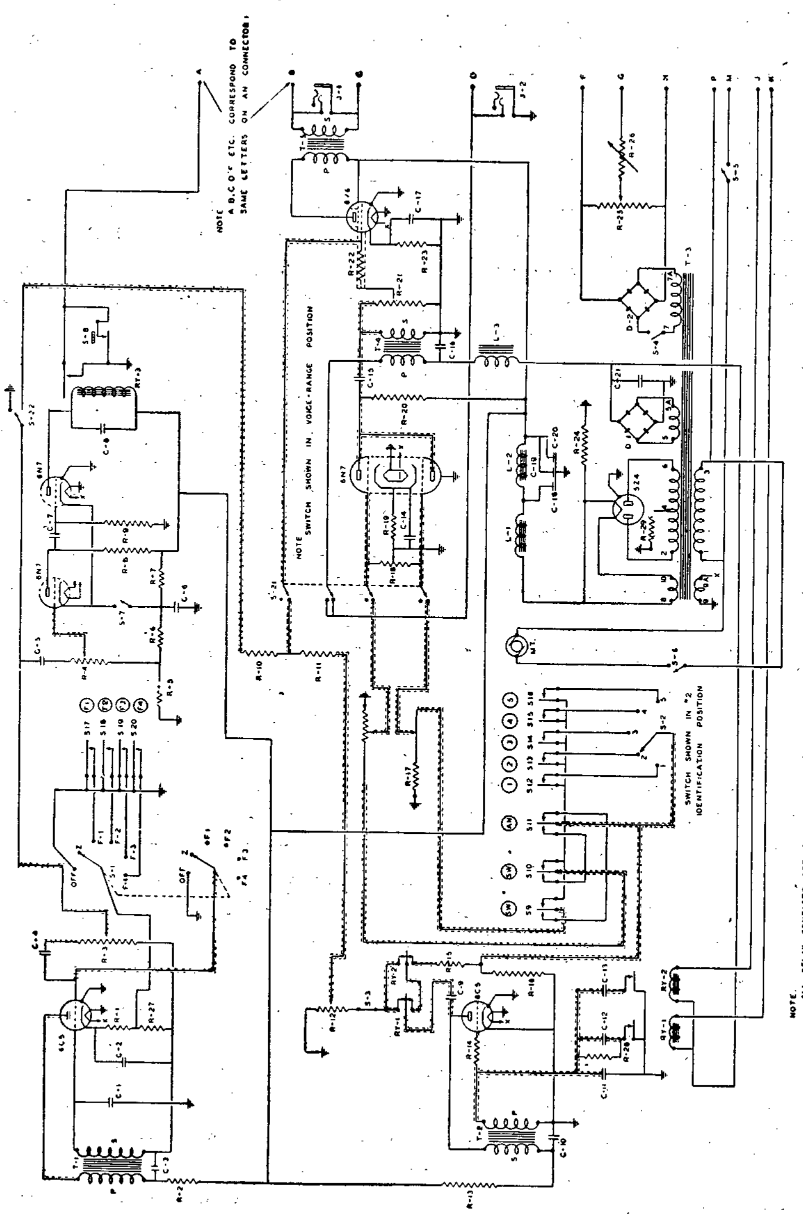


FIGURE 149.—Wiring diagram, C-3 radio chassis.

the inner position, relay RY-2 is operated and relay RY-1 is released. With relay RY-2 closed, the capacitor C13 is shunted across the resonant circuit producing a frequency of 400 cycles per second. Additional contacts on RY-2 complete the circuit through switch S-3 and volume control R-12 as before. This signal then simulates the inner marker beacon of the Army Air Forces instrument landing system.

(*c*) The marker beacon oscillator circuit utilizes a type 6C5 tube in conjunction with an oscillation transformer T-1. Capacitor C1 shunted across the transformer secondary forms a resonant circuit which produces a frequency of 3000 cycles per second. The output of the oscillator is applied to potentiometer R-3, the setting of which determines the magnitude of the signal output. A portion of the signal is applied through S-22 and S-21 to the grid of the 6V6 amplifier tube. The remaining portion of the signal serves to operate the 6N7 relay tube in such a manner that each signal pulse closes relay RY-3. The relay in turn closes a circuit to an indicator lamp on the instrument panel thus giving visual indications of the marker beacon signals. A switch S-7 is provided for the purpose of removing visual signals if desired while a push button switch, S-8, enables the instructor to give additional visual signals other than those provided.

(*d*) The output of the keyer is applied to the beam shift control R-17 and thence to the grids of the 6N7 mixer tube. The output circuit of the mixer tube is capacitively coupled to the voice-range volume control R-21. The microphone transformer is also connected across this same control, the combined voice and range signals being applied to the grid of the 6V6 amplifier tube. The output circuit of the 6V6 amplifier tube consists of a transformer which couples the tube output to the headphones in the desk and the fuselage.

(2) *Radio range keyer.*—(*a*) This device automatically produces A-N signals, fan markers, and station identification signals. The main cam assembly (fig. 150) with its several pairs of call letters may be replaced in a few seconds with an assembly providing entirely different letters. The gearing of the camshaft is selected according to the type of current specified with purchase. The motor is a constant-speed type and requires no adjustment.

(*b*) The purpose of the keyer is to take a steady tone which is produced by the trainer radio and break it up into A's and N's, station identification letters, and marker signals. The steady note, or signal, is given a choice of routes from inside the control chassis to the keyer and back again into the control chassis. This signal is made to produce A's and N's, when routed one way, and identification letters when switched through the other routes.

(*c*) A's and N's are produced by one cam and three contacts. Two of the contacts are fixed and the middle one is actuated by the cam. The high parts of the cam press the movable contact against the outer of the two fixed contacts and produces A's while the low parts of the cam produce N's in the same manner from the inner fixed contact. The points are so adjusted that the movable contact is making connection at all times either with the outer or with the inner fixed contact. Thus, the dit of the A fills the space between the dah and dit of the N and the dit of the N fills the space between the dit and dah of the A. Thus, when the signals produced by both sets of contacts are heard with equal intensity, a continuous monotone results. The current for the A's and N's leaves the beam oscillator circuit of the radio chassis on a wire which connects to the middle (movable) contact of the A–N cam. This cam presses the movable contact alternately against the two fixed contacts in such a manner as to produce A's and N's. These contacts are adjusted so that the moving one makes contact with one of the fixed points at the same instant it breaks contact with the other. Thus, there is no overlap, yet current is flowing continuously through either one or the other. From the keyer A–N contacts the current travels back to the A–N mixture control where the A's and N's are blended into various radio range characters, as explained in the radio description.

(*d*) The on-course, or series of 12 A–N interlocks, occupies approximately 30 seconds. That is, the A–N cam is in operation for 30 seconds and then it is interrupted electrically while two sets of station identification letters are sent. This is accomplished by the switching cam assembly on the right-hand end of the keyer. Two cams and two sets of contacts are provided on this assembly, driven by a ratchet and ratchet cam assembly, which advances one notch with each revolution of the main cam assembly. These sets of contacts interrupt the A and N current supply and switch the current through the station identification cam contacts instead of through the A–N contacts.

(*e*) During the 30 seconds of the A's and N's, these points are closed as in position "A," figure 150. At the end of the 30-second period, both contacts are opened, thus interrupting the current to the A–N cam contacts. At the same time the contact in the N circuit of the switching cam contacts is permitted to move far enough to make contact with the fixed contact, position "B," figure 150, which is connected to the common wire connecting the station identification cam contacts during one revolution of the main cam assembly. The station identification is thus transmitted to the N side of the mixture control. The ratchet then advances the switching cams another notch,

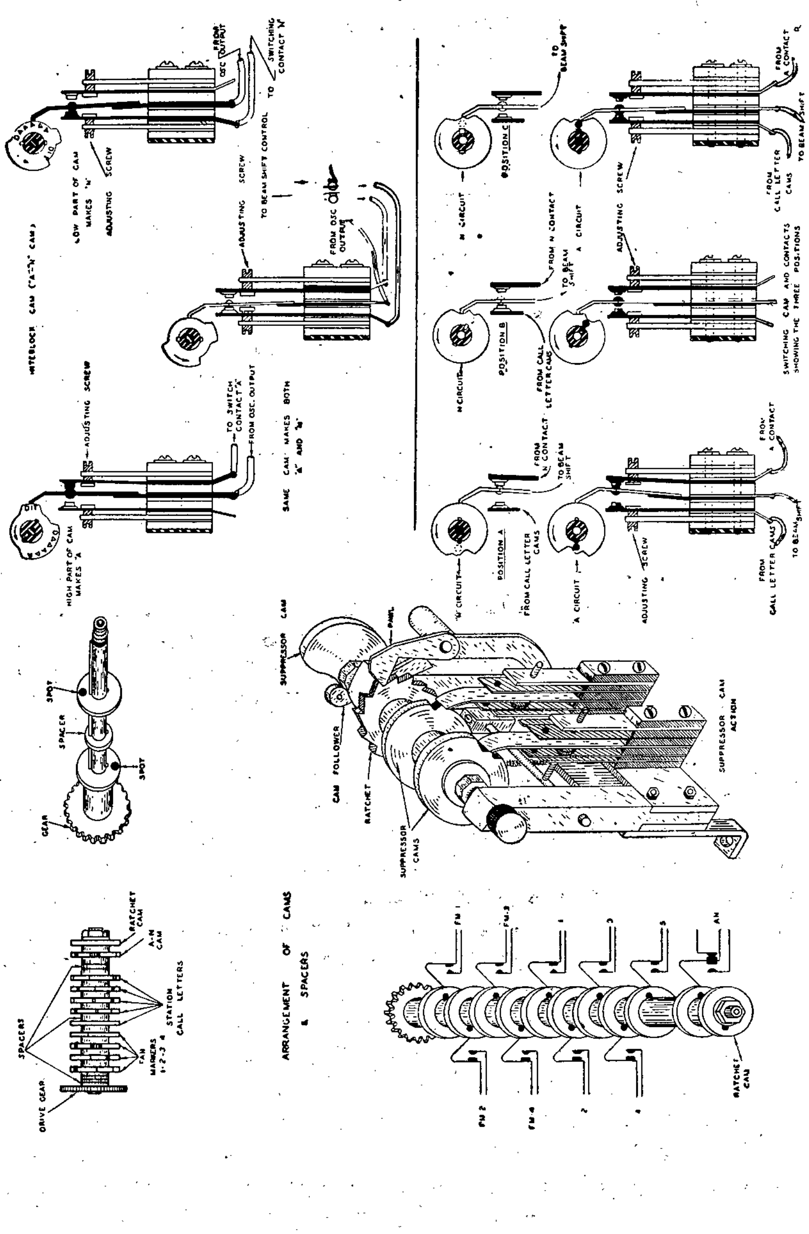


FIGURE 150.—Radio range keyer cams and contacts.

which allows the movable contact on the A circuit as in position C, to make contact during the next revolution of the main cam assembly. The station identification call is repeated and transmitted through the A side of the mixture control. With the next notch moved by the ratchet the cams push the contacts back to their original position, making the circuit complete again on the A–N cam contacts.

(*f*) Five different station identification calls are provided. The same tone used for A–N signals is used for station call letters but is handled differently. Through a selector switch located on the control chassis, any one of the five stations may be selected. If spare main cam shaft assemblies are available to provide additional station calls, the change can be made in a few seconds. Simply unscrew the knurled nut on the end of the cam shaft bearing pin and pull it out about two thirds of the way. (This shaft has a left-hand thread; turn right to remove.) The shaft should be pulled out only far enough to clear the main cam assembly without releasing the switching cams. While pulling out the pin shaft, hold the main cam assembly with one hand and lift it out as the pin shaft clears it. In replacing the unit, ease it into place carefully so as not to damage the cam followers or contacts. No timing is necessary as this is taken care of in the main cam assembly.

(*g*) Keying of the fan markers is arrived at differently than in the method of keying A's and N's and station identification calls. Instead of keying the oscillator output, the keyer contacts close the circuit of a high resistance R–27 (fig. 149) to ground, which starts the oscillation of the marker circuit. This manner of keying eliminates the undesirable "key clicks" of the fan marker contacts. The fan marker cams are cut differently for proper coding of radio signals. Different characters for the four fan markers and "Z" markers are obtained on the five position selector switch.

(*h*) When the selector switch is in the "Z" marker position the circuit is continuously closed and the high frequency resistor R–27 (fig. 149) circuit is shorting to ground allowing oscillation to take place in the marker oscillator tube as long as the switch is closed.

(*i*) The main output for all circuits including mixture control and keyer A–N circuits are shielded to prevent induction of signal and insure minimum interference between the various circuits.

47. C–5 radio equipment.—*a. General.*—(1) To provide the pilot with a means for navigating by use of radio aids and for practicing instrument landings, two radio transmitters are provided in the operator's desk. In all trainer models which precede the C–5, the radio was an audio amplifier similar to a public address system. The

keyed output of the oscillators was led through wires from the desk through the trainer spindle into the fuselage. Provision for voice communication was made and controlled by the operator through a selector switch. No tuning was necessary. In the C–5 radio, however, the signals are produced by two actual radio transmitters operating on any frequency (controllable by the operator) between 200 and 400 kc, using A–2 and A–3 types of emission. Separate provision is made for direct telephonic communication between the desk and the trainer whenever desired. Voice communication alone, simultaneous radio range and voice signals, "control tower" on 278 kc, instrument landing signals, and signals on which radio direction finding may be accomplished, are all available. The transmitters are provided with five different sets of radio range identification signals. Each transmitter has separate controls for volume, to simulate distance from the station, as well as azimuth controls for radio direction finding work. As many different stations as desired may be "worked", it being necessary only to change the frequency, and reset up the problem conditions on one station while the pilot is tuned to the other.

(2) Control tower communication on 278 kc is provided for through the modulation selector switch. None of the signals produced by the transmitter are audible unless the trainer receiver is tuned to the frequency set up at the transmitter. A standard aircraft receiver capable of receiving signals in the 200–400 kc band is used in the trainer fuselage. It is provided with a two position selector switch which provides for reception on loop only or reception on omnidirectional antenna only.

(3) For instrument landing practice, one of the transmitters is modulated at 400 and the other at 800 cycles. A light is provided on the instrument panel which simulates the station location markers used in the Army system of instrument landings. Visual L–R radio compass indications are produced the same way as in all other models of the trainer.

(4) Noise interference can be fed into the transmitters by using a standard receiver to pick up outside signals or static, thus enabling the operator to simulate more closely the quality of signals found in actual practice. This receiver is not supplied as part of the equipment.

b. Uses.—The C–5 trainer radio provides the following:

(1) *Simultaneous radio range and voice transmission.*—Choice of five radio identification signals for range orientation—two stations operable simultaneously.

(2) *Radio direction finding.*—May be accomplished on any type modulation provided by the modulation selector switch. For D. F. the trainer receiver selector switch must be in the "loop reception only"

position. Thus, R. D. F. may be practiced on two stations (or any number of stations for consecutive bearings) on any combination of the following: radio ranges, unkeyed 400 to 800 cps tones, or externally modulated signals such as broadcast stations, outside radio ranges, etc., the signals from which are fed into the trainer transmitter from the interference receiver.

(3) Control tower communication on 278 kc.

(4) *Instrument landing system.*—Radio compass (army) system using two transmitters on two different radio frequencies, an inner and an outer marker beacon on simulated 75 megacycles.

(5) Interphone communication, at any time, between instructor and trainer occupant.

(6) Noise interference.

(7) Receiver handling practice.

c. General description.—(1) The radio in the trainer desk consists of two transmitters; one on each side of the centrally located control chassis (fig. 58). Both transmitters (fig. 151) are provided with controls for—

(*a*) Radio frequency tuning.

(*b*) Azimuth.

(*c*) Volume.

(*d*) Modulation selector—for range (simultaneous)—control tower on 278 kc.—instrument landings—and external modulation.

(2) The control chassis (fig. 152) is provided with the following controls:

(*a*) Two A-N mixer controls (beam shift).

(*b*) Two identification selector switches (five positions).

(*c*) One marker beacon selector switch (six positions: OFF, Z, F1, F2, F3, F4).

(*d*) One marker beacon volume.

(*e*) Two noise selector switches (three positions each: OFF, #1, and #2).

(*f*) Two noise volume controls.

(*g*) One push-pull radio-interphone switch.

(*h*) One interphone volume control.

(*i*) Master radio on-off switch.

(*j*) Keyer on-off switch.

(*k*) Visual marker push button.

(*l*) Visual marker on-off switch.

(*m*) Aural marker on-off switch.

NOTE.—For purposes of identification the transmitter on the left hand (fig. 58) will be referred to hereafter as radio station "A"—that on the right as radio station "B".

(3) The trainer receiver (fig. 111) is mounted on the instrument panel within the trainer fuselage. It is a standard aircraft receiver covering the 200–400 kc band and is provided with both loop and omnidirectional antennae, choice of either of which is obtainable through a selector switch on the receiver. Since the signals produced

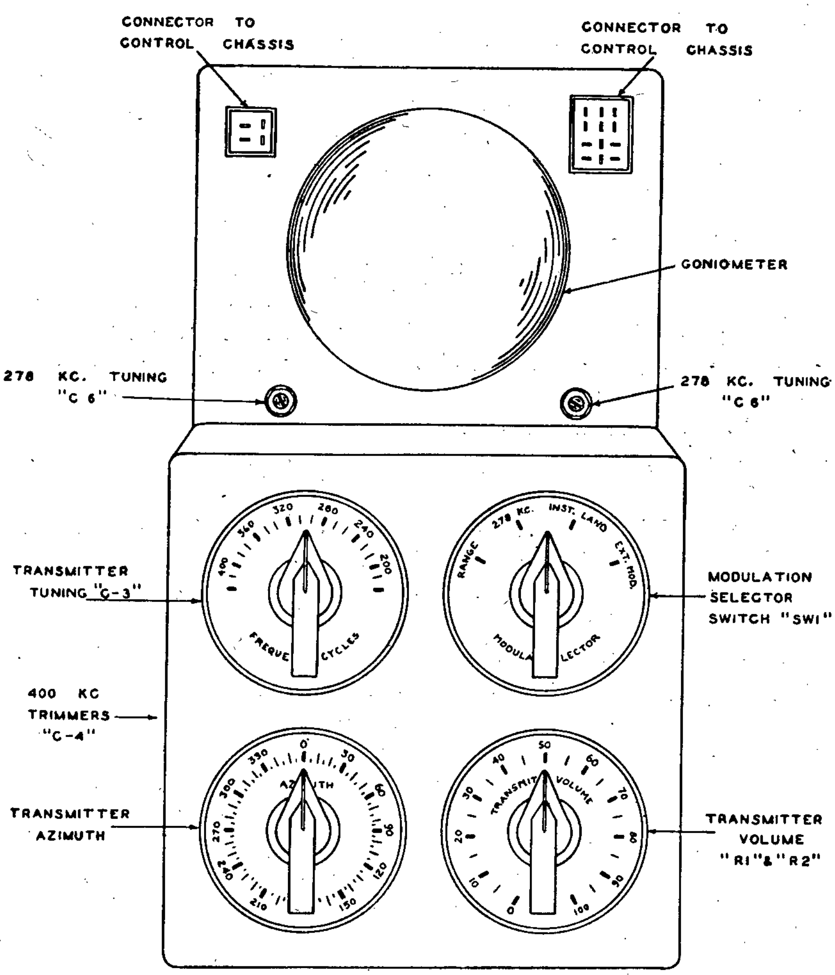


FIGURE 151.—Radio transmitter control, C–5.

by the transmitters are not audible unless the receiver is tuned correctly, practice in receiver handling is thus made possible.

(4) The loop azimuth control used in radio position fixing is of the wheel type and is located within the trainer hood, forward and above the student's head. The azimuth scale is illuminated by a "pilot light" type bulb. Errors similar to the quadrantal errors which

exist on standard loop installations also exist in the trainer installation. A correction card is provided so that these errors may be taken into account. However, all quadrantal errors may be removed by the instructor if so desired during preliminary instruction of pilots who are inexperienced at radio direction finding.

(5) The transmitting antenna which is fed by the transmitter in the desk drawer, is located in a wooden box directly above the loop receiving antenna which is mounted on top of the trainer hood. The box contains two crossed loops which are connected to goniometer coils in the transmitter unit. The receiver loop is a standard loop antenna whose axis is in line with the axis of the cross loops in the transmitter loop box.

(6) The instrument landing system consists of controls for producing unkeyed signals modulated at 400 and 800 cycles per second, respectively; and switches for marker beacon lights on a simulated 75 megacycles. In addition, a radio compass left-right indicator is provided on the instrument panel which is controlled as previously described.

d. Interference receiver.—(1) The noise interference receiver which may be located conveniently near the operator's desk should consist of any standard radio receiver covering whatever frequency bands may be desired. It serves two purposes:

(*a*) It provides noise interference in the form of static, other range stations, etc., to be used along with the clear signals produced by the trainer transmitter, thus making these latter signals sound like they do in actual practice.

(*b*) It provides types of modulation other than those produceable by the trainer transmitter on which radio direction finding problems may be worked.

(2) The output of this receiver is fed into the trainer transmitter after the desired "noise" is tuned in and the volume set to a comfortable level. After that it is completely controllable by the controls in the desk drawer. It may be turned on or off at will, or the volume may be controlled within wide limits by the controls in the desk drawer.

e. Detailed description.—Functions of the controls of the radio in the desk drawer (fig. 151), transmitter boxes "A" and "B":

(1) *Radio frequency control.*—Used for tuning the radio transmitter between 200 and 400 kilocycles. Frequency of stations in a problem is predetermined by the instructor. ***Caution:*** When two stations are being used, select frequencies which are more than 15 kc apart. Otherwise interference between the two transmitters results,

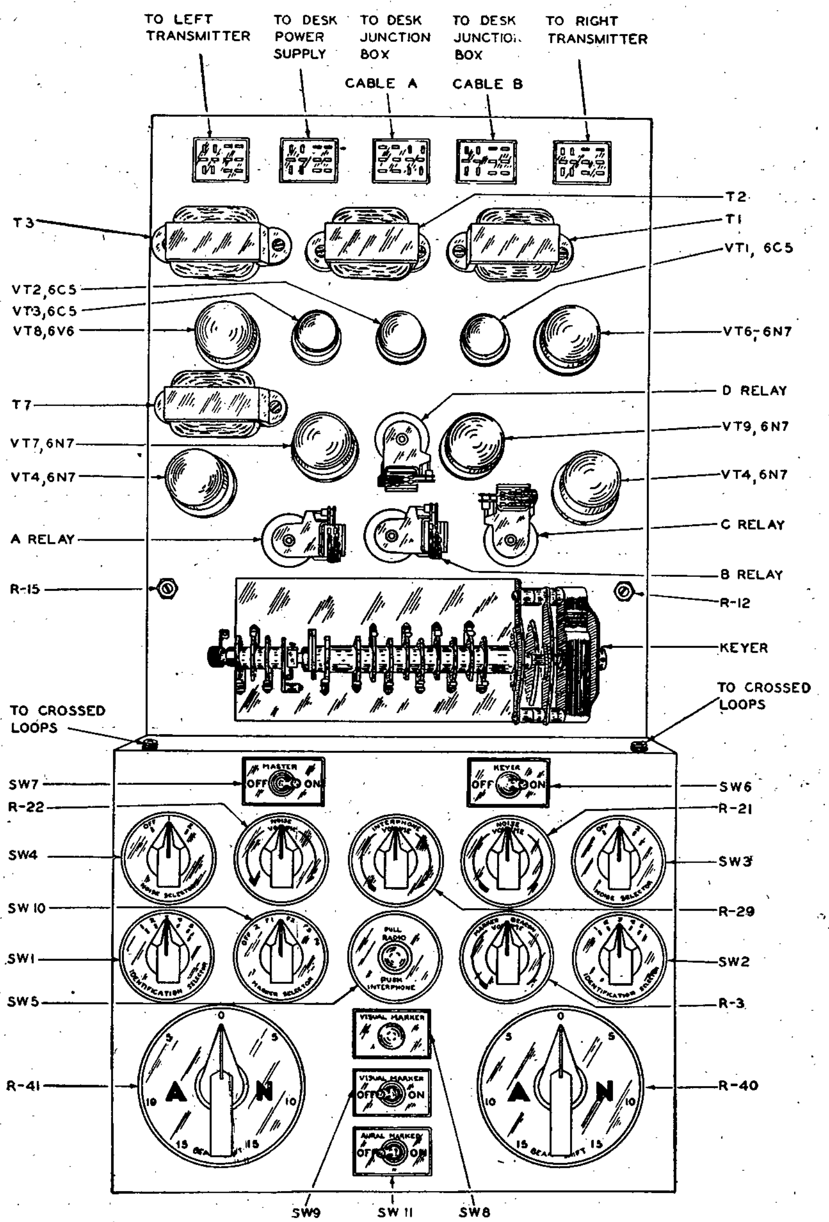


FIGURE 152.—Radio control chassis, C-5.

making the transmitters squeal if the frequency controls are moved closer than approximately 15 kc apart.

(2) *Azimuch controls.*—Used only when giving direction finding problems. They control the electrical angular relationship between the receiver loop and transmitting antennae in the loop box. By setting the bearing of the aircraft from the radio station on this control, the relative bearings of the station can be obtained with the receiver loop, and the magnetic bearing derived in the usual manner.

(3) *Transmitter volume.*—Used for simulating distance from station. Position of the knob dependent on the relative scale of distance between recorder inking wheel and radio station as represented on the chart.

(4) *Four-position selector switch.*—(*a*) Simultaneous voice-range (Sim. V. R.). Transmitter produces radio range signals. Operator is able to broadcast at the same time.

(*b*) 278 kc (control tower) voice transmission on 278 kc. The receiver must be tuned to 278 kc. For use in practicing control tower procedure and communication, also receiver handling.

(*c*) Instrument landing—for producing unkeyed signals used in instrument landings. These signals may also be used in radio direction finding if desired.

(*d*) Ext. Mod. meaning external modulation. For use when outside signals are desired for use in radio position finding problems.

f. Control chassis (fig. 152).—(1) A–N mixer controls, used to blend A's and N's together with varying value of background strength. One for each transmitter.

(2) Identification signal selector switch, for providing choice of range stations. One for each transmitter. Choice of five different sets of identification letters.

(3) Marker beacon selector switch (six positions) "OFF," "Z", "F1", "F2", "F3", "F4" for producing "Z" or cone of silence markers and fan markers keyed for 1, 2, 3, or 4 dashes respectively.

(4) Marker beacon volume, for controlling volume of marker beacon tone to simulate distance from markers.

(5) Noise selector switches (two) one for each transmitter—to provide interference (noisy range or D. F. signals) whenever desired.

(6) Noise volume controls (two) one for each transmitter, used for controlling the volume of the interference. Select original volume desired, controlling subsequent signals with transmitter volume.

(7) Radio-interphone switch: Normally used in radio position (pull). Should trainer occupant get confused and tune receiver

improperly, or at any time it is desired to talk to trainer occupant when receiver is not tuned to frequency, communication can be established by pushing the button for interphone communication. This provides a direct phone line which does not pass through the trainer receiver.

(8) Interphone volume control for degree of volume of voice.

(9) Master radio ON–OFF switch: must be turned on before radio can be operated.

(10) Keyer ON–OFF switch controls keying unit after master switch is ON.

(11) Visual marker push button—lights a marker light. Whenever visual marker signals are desired for which there is no provision on the radio, this button may be used. The visual marker switch must be "on" to operate the light.

(12) Visual marker ON–OFF switch—controls the circuits for all the visual markers.

(13) Aural marker ON–OFF switch—controls the circuits for all the aural markers.

g. Transmitting and receiving loops.—(1) *General.*—The output of each transmitter is led through a goniometer to two rectangular fixed crossed loops in the loop box. (The goniometer, of which there is one for each transmitter, is controlled by the transmitter azimuth control.) The wooden box containing the transmitting antenna is suspended above the trainer hood. Its dimensions are approximately 40 by 40 by 9½ inches. The axis of the rotatable receiving loop which is mounted on the trainer hood is in line with the axis of the two crossed rectangular transmitting loops located within the box. The rotatable receiving loop itself is conventional in construction; that is, the outer aluminum shell is split at the top.

(2) *Principle of operation.*—Depending on the position of the goniometer rotor, a certain field pattern is set up around the goniometer rectangular loops due to the current induced in each rectangle by the rotor. The goniometer loops are connected directly to the two crossed rectangular loops in the box, hence the latter have a like current passing through them. This current sets up a field pattern identical to the one at the goniometer. So, induced in the receiver loop is a current, the strength of which is dependent on the angular relationship between the equatorial axis of the rotatable loop and the center line of the pattern. Thus, any directional pattern may be set up around the transmitter loops by rotating the transmitter azimuth control to the bearing of the station from the aircraft. Then nulls may be obtained with the loop in two positions, 180° apart.

These positions, it has been shown, are dependent on trainer heading as well as loop azimuth control setting.

(3) *RDF quadrantal error and correction card.*—"B" transmitter correction card: When the transmitters are used for direction finding, a correction for loop error should be determined and applied to the loop azimuth control indication in order to obtain the relative bearing. This error corresponds to the quadrantal error found on standard loops, for which either a table of corrections or a graph is provided at the receiver. In the C–5 a smiliar correction card is necessary at the receiver if actual conditions are to be simulated. These errors may be completely obliterated, however, if the operator applies the indicated correction when setting the azimuth control. This may be desirable when instructing inexperienced pilots in the art of direction finding. When both transmitters are used for position fixing, an additional correction must be applied to one of the transmitter azimuths in order that only one correction card be necessary in the trainer. This is due to the fact that the loop or quadrantal errors differ slightly between the two transmitters. When using the right-hand or "B" transmitter, the operator must note on the "B" azimuth correction card the figure that would be obtained if the left-hand or "A" transmitter were being used.

(4) *Correction cards.*—A total of three correction cards, therefore, is necessary—one for the pilot, an identical one for the trainer operator, and one for correcting the "B" transmitter azimuth indication in the radio drawer to make it agree with the "A" transmitter.

NOTE.—Since these units are really radio corrections similar to those necessary in aircraft, these corrections must be expected.

(5) *Procedure for making out the correction cards.*—Using the transmitter on the left ("A" transmitter), have an assistant obtain nulls 30° apart, noting the error. If the trainer is turned to the north position, set the transmitter azimuth to zero. The assistant should then obtain the null on zero, plus or minus the amount of error. If the loop scale reads 3 the error is plus 3. Next, set the transmitter azimuth to 30. The assistant should then obtain the null on 30, plus or minus the error. Continue the process all the way around the 360°. Make up two quadrantal error graphs—one for use by the pilot, the other for use by the trainer operator (should he wish to give bearings with zero error to beginners or to check on the pilot's efforts at the conclusion of the problem). Next, repeat the procedure using the transmitter on the right ("B" transmitter), except that no curve need be drawn up. Since it is possible to give the pilot a corrected relative bearing (a bearing with zero quadrantal or loop error) mere-

ly by setting the transmitter azimuth to the bearing, plus or minus the error as indicated on the error card, so it is possible to remove the error, if any, between the two transmitters by turning the "B" transmitter azimuth to the correct bearing, plus or minus the *difference* between the two transmitter errors.

Example: If the transmitter azimuth control is on 90 and the quadrantal error with transmitter "A" is plus 5 and with transmitter "B" is plus 2, the "B" transmitter azimuth should be turned to 90 plus the *difference* between the two. In this case, turn the "B" azimuth to 93, since the "A" transmitter is 3° more in error than the "B" transmitter. The pilot, then, by applying the 5° correction indicated on his error card or graph obtains the correct relative bearing. Essentially, having in mind the "A" and "B" errors, determine how many degrees and the direction in which the "B" knob must be moved in order to give the "B" transmitter the same error that "A" has.

Examples:

To get a "B" error of—	To agree with an "A" error of—	"B" transmitter azimuth control correction must be—
−1	−3	−2
−5	−3	+2
+1	+3	+2
+5	+3	−2
−1	+3	+4
+1	−3	−4

It can be seen from the description of the principle of operation of the transmitting and receiving loops that the loop box must be accurately orientated in order that errors in relative bearings, magnetic bearings, and loop be kept at a minimum. Orientation of the loop box is done in the original installation and should remain fixed. However, if errors become apparent over a period of time, this item should be checked as one of the possibilities which effect error.

h. Instrument landing system.—The C-5 radio is provided with controls which produce the visual and aural signals used in the Army instrument landing system. The requirements for this type of instrument landing system and the location of the controls is as follows: Radio compass left-right indicator located on the pilot's instrument panel. This instrument is operated by the radio compass control which is located on the top recorder plate. Two locater stations are required. Both of these are modulated with unkeyed signals—one modulated at 800 cycles, the other at 400 cycles. These signals are produced with the modulation selector switch turned to instrument landing position and the volume controlled by the transmitter volume control. The radio frequency is set up on the frequency control. The

outer and inner visual markers are obtained by use of the visual marker on-off switch and the visual marker push button.

i. Interference receiver.—The interference source output (fig. 153) is fed into the trainer transmitter through terminals in the junction box at the rear of the desk. At the receiver end the wires are led off the plate of the output tube through a blocking condenser. Insert switch in lead to speaker voice coil and connect capacitor to plate of output tube. Insulate carefully, since there is high voltage on this tube. Run wire from other end of capacitor to desk junction box terminal.

j. Radio—How to operate.—First make sure all switches, including selector switches, are "off" and all volume controls are at maximum resistence (minimum volume).

(1) Turn "on" trainer master switch.

(2) Turn "on" radio master switch.

(3) Turn "on" keyer switch.

k. For simultaneous voice-range transmission and reception.—Either transmitter "A" or "B":

(1) Set selector switch on range position.

(2) Set radio frequency to that desired.

(3) Set transmitter volume to position which is consistent with distance of inking wheel from radio station on charts. (This must be controlled throughout the problem.)

(4) Set A–N mixture control in proper position—according to inking wheel location. (Must be continuously operated according to inking wheel position.) The pilot must now tune receiver to proper frequency, switch to omnidirectional antenna, etc. (If pilot calls control tower—move selector switch on transmitter to 278 kc. Pilot must tune receiver to 278 kc. to receive signal.)

l. For R. D. F. Station "A" or "B".—Receiver selector must be on "loop reception only". R. D. F. may be done on radio range signals, instrument landing unkeyed notes, or external modulation.

(1) Master switches and keyer switch "on."

(2) Set frequency and transmitter volume.

(3) (*a*) For range signal D. F. set selector switch to "Range" position.

(*b*) For unkeyed note, set transmitter selector switch to "Inst. land." position.

(*c*) For external modulation, set selector to "External modulation."

(4) Set azimuth control to Q. D. R. and maintain the proper setting as inker progresses across chart.

m. For instrument landing.—(1) Turn master switch "on" and modulation selector to "Inst. land."

(2) Set frequency controls, outer station 219 kc, inner station 201 kc. (If other frequencies are used, keep them approximately 20 kc. apart, tuning the outer station higher than the inner. The aural tone of the outer is higher (800 cps) than the inner station, which is 400 cps.)

(3) Set volume controls. (Must be operated throughout.)

(4) Turn "on" visual marker switch.

(5) When inking wheel passes over markers, push visual marker push button.

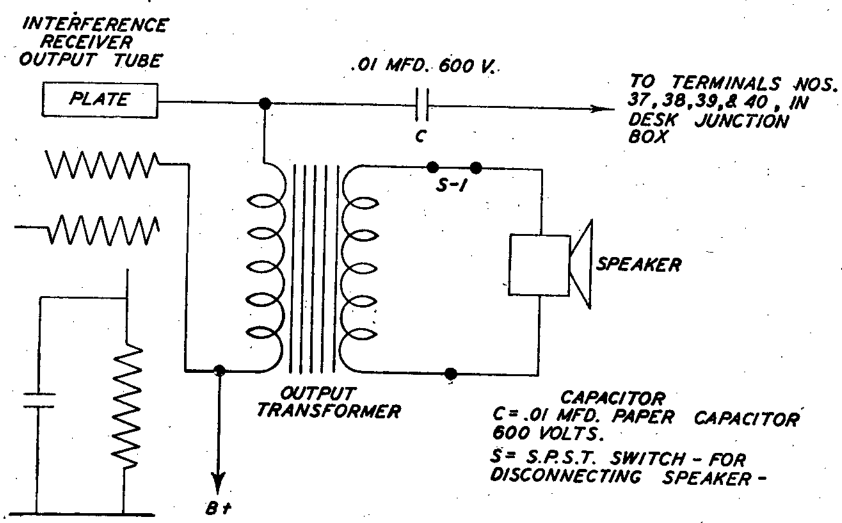


FIGURE 153.—Interference receiver hook-up, C-5.

(6) Use radio compass control on top of recorder to give L-R visual indications on radio compass indicator.

NOTE.—Receiver selector switch should be in "Omnidirectional only" position.

n. Receiver handling.—The receiver in the trainer must be handled exactly the same as any radio receiver, since the signals from the transmitters are emitted as from any radio transmitter. The receiver must be tuned to the proper frequency and the volume controlled properly to prevent blocking. R. F. gain control must be properly handled to give the most clearly audible tone, etc. For radio range work (except directional finding) receiver selector switch should be on "Omnidirectional antenna".

NOTE.—The interphone-radio push-pull button switch can be used by the operator at any time, when it is possible to establish communication with the pilot due to improper tuning or handling of the receiver. This switch cuts out the radio entirely and establishes direct telephone communication between desk and trainer. During normal operation, the switch should be kept in the "radio" position.

o. Do and dont's.—(1) Turn on master radio switch to operate radio.

(2) Keyer switch must be on before keyed signals can be produced.

(3) Do not use two radio frequencies which are less than 15 kc apart, squealing results.

(4) Do not use noise volume controls for simulating distance from station. Leave them set. Use transmitter volume controls.

(5) Tune receiver properly if signal is to be expected.

p. Detailed description of assemblies.—The two transmitters located one on each side of the control chassis in the middle desk drawer are identical units and interchangeable. Either may be removed merely by disconnecting two Jones plugs. The output of each unit is fed through two shielded transmission lines directly to the crossed loops over the trainer hood. In connection with the following description, see wiring diagram 154.

(1) *Transmitters, C–5 radio.*—The RF carrier is generated in the oscillator section of Vt. 1, a 6K8 type tube containing a triode and pentode section in one envelope. The triode section of the 6K8, the oscillator coil T1 and the tuning condensers C3, 4, 5, 6, and 7, comprise the oscillator circuit. The oscillator voltage is injected within the tube into the pentode amplifier section. The modulation voltage provided in the control chassis and selected by the selector switch Sw 1 are applied to the control grid of the pentode section which is the cap of the tube. Modulation takes place within the pentode section. In the plate circuit of the pentode tube is provided another tuned circuit comprising transformer T2 together with another set of capacitors C3, C4, C5, C6, and C7 for tuning purposes. Coupled to the tuned circuit in the plate of the pentode section is a link circuit which couples the output of the pentode section to the rotor of the goniometer. The position of this rotor determines the magnitude of the currents in the cross loops and therefore the apparent position of the two nulls which rotate around the receiver loop on the trainer hood. Tuning throughout the range 200 to 440 kc is provided by condenser C3, a two-gang affair, one section of which tunes the oscillator section triode and the other section of which tunes the pentode amplifier section. Transmitter azimuth is controlled by means of the position of the rotor in the goniometer. This is driven by a phospher bronze cable by the control marked "Transmitter azimuth". The transmitter volume control R1 and R2 on the wiring diagram is a two-section control, one section (R2) which varies the bias and therefore the RF output of the transmitting tube. The second section (R1) varies the amount of modulating voltage applied to the pentode

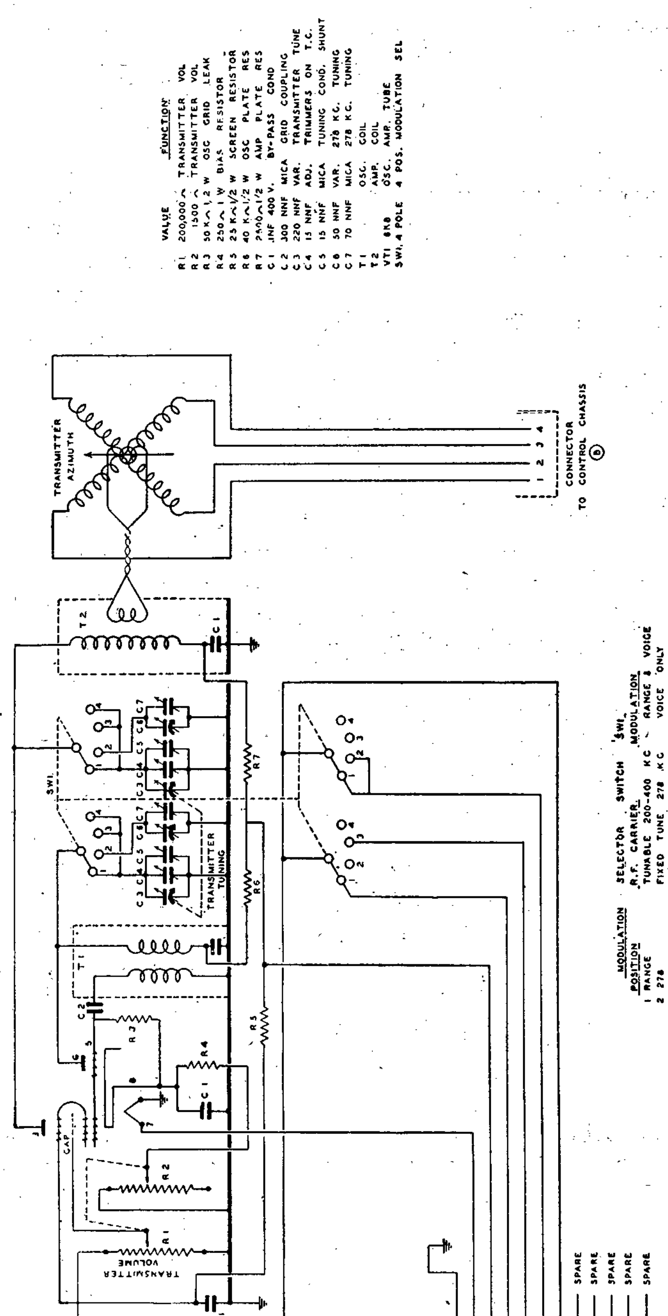


FIGURE 154.—Radio transmitter wiring diagram, C-5.

section. At maximum volume position, the bias on the tube is minimum and the radio frequency carrier output maximum. As well, the modulation voltage applied to the control grid has maximum volume. This voltage is between 15 and 21 volts for either voice or tone modulation. At minimum volume position of the transmitter volume control, the bias on the tube is maximum and the modulation voltage is minimum. The connector (A) to the control chassis provides operating and modulation voltages. Connector (B) to the control chassis takes the output of each transmitter goniometer and connects them in parallel in the control chassis. The output of the two coils in parallel is in turn fed to the cross loop assembly.

(2) *Control chassis*—(*a*) Reference is made to figure 155 which is a wiring diagram of the control chassis for C–5 radio. The function of the control chassis is to provide modulation voltages for the transmitters, both left and right. All modulation voltages, both steady tone and voice, are generated and controlled in and by the control chassis. Taking first the A–N tones for radio range problems and starting with the tube VT2 on drawing No. 152, it will be noted that this tube is connected as an audio oscillator. The output voltage of this oscillator appears across resistor R6 providing a low impedance source of excellent regulation, thence to the "D" relay and to the A–N cam #10. The output of the A–N cam is connected in parallel only during the A–N periods. From the beam shifts (A–N mixers) the signal is fed to the beam shift buffer amplifiers which further amplify this signal. The output of the buffer amplifiers is fed to the beam shift centering controls R12 and R15 and then to the "B" relay. The "B" relay normally is closed and is operated by the simultaneous voice range switch on the fuselage control box. If the simultaneous voice range switch is in either "simultaneous" or "range" position, the "B" relay remains closed and the A–N tone is applied to the transmitters. During the identification period, relay "D" is operated by cam 13 on the low speed shaft of the keyer. The "D" relay transfers the range tone from the A–N cam #10 to the identification cams, 5, 6, 7, 8 and 9. At the same instant the two beam shift controls are disconnected from each other by other contacts on the "D" relay the identification characters selected by switch 1 and switch 2 are fed to the beam shift controls through the switching cams 12 and 14. For voice modulation of the transmitter used during simultaneous voice range transmission and control tower transmission, the microphone voltage applied at transformer T6 goes through interphone radio switch (switch 5) through the "A" relay to the grid of the voice amplifier tube VT7, the output of which is

fed to each transmitter. Should the simultaneous voice range switch be in either "simultaneous" or "voice" position, the "A" relay will open and disconnect the microphone transformer from the grid of the voice amplifiers thus rendering no voice modulation to the transmitters.

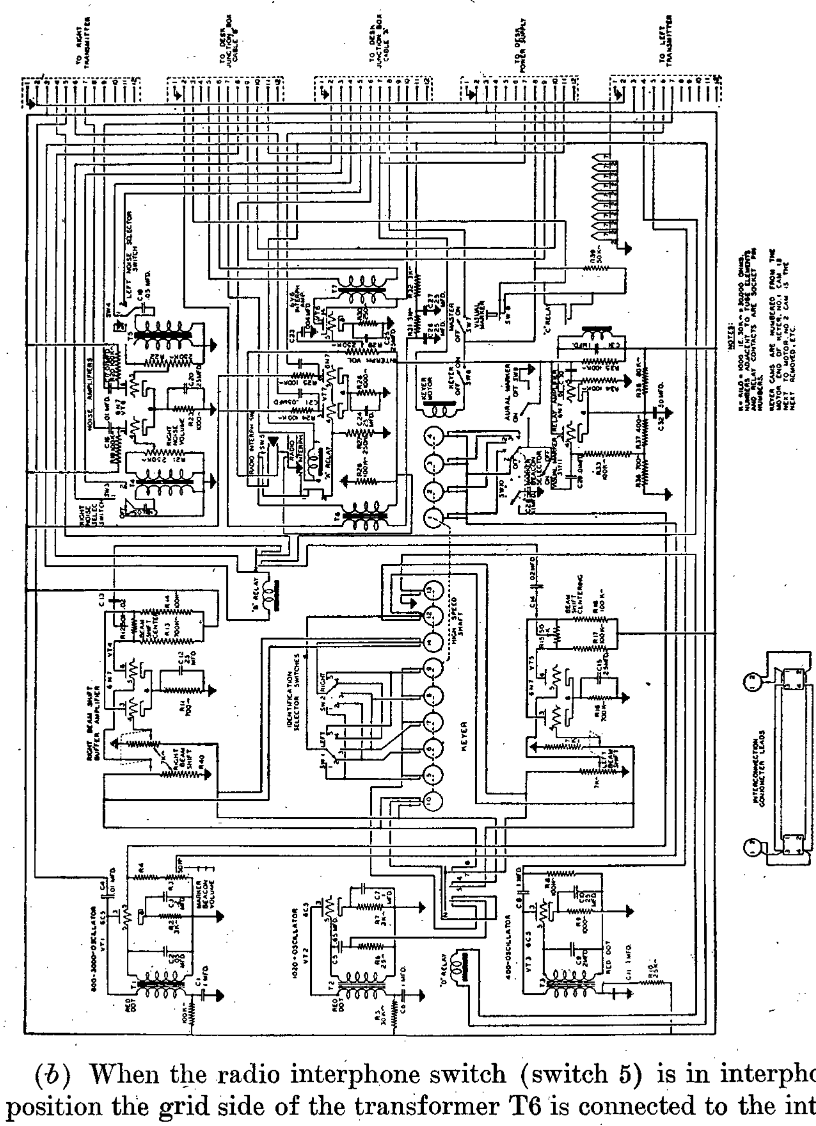


FIGURE 155.—Control chassis wiring diagram (C-5 radio).

(*b*) When the radio interphone switch (switch 5) is in interphone position the grid side of the transformer T6 is connected to the interphone volume control and from thence to the grid of the interphone amplifier tube VT8. The output of this amplifier is transformer coupled by transformer T7 to a 500-ohm line which runs to the instructor's

headphones and pilot's headphones at the fuselage control box. For the generation of marker signals, both aural and visual, the output voltage of the 800–3000 cycle oscillator VT1 is taken off of the marker beacon volume control R3, fed to marker cams 1, 2, 3 and 4, selected by marker beacon selector switch SW–10 and to the aural marker on-off switch (SW9) to the low side of the microphone transformer and then to the grid of the 6V6 interphone amplifier to the pilot's headphones. Should visual marker on-off switch SW–11 be closed, the keyed signal will appear at the input grid of the relay amplifier tube VT9 where it is amplified, coupled to the second grid and rectified. This rectified signal operates "C" relay which in turn causes the marker beacon flasher lamp on the instrument panel to light in accordance with the keyed signal. Should the instructor desire only visual signals, the aural marker switch SW–9 is turned to the "off" position. Should the instructor desire only aural signals the visual marker switch (SW–11) is turned off. Should a condition arise where the instructor desires to flash the marker lamp on the instrument panel, he may do so with visual marker switch (switch 8).

(*c*) For more accurately simulating radio problems in the trainer, interference or noise amplifiers are built into the radio system. These amplifiers function as follows: An external source of noise or any other type of interference is connected to the desk junction box, fed to the control chassis and by means of selector switches selected. The motor is controlled by the noise volume control, then amplified and fed as modulation voltage to one or the other of the transmitters. Should an external source of noise such as a radio receiver tuned between stations producing static be connected, this voltage applied as modulation voltage to the transmitter, the resultant signal out of the transmitter will sound much the same as does a radio receiver when operated under conditions of heavy static. Should it be desired to modulate the transmitters with a signal such as is not provided by any of the modulation voltages in the control chassis, this may be done by connecting this external signal to appropriate terminals in the desk junction box and turning the transmitter modulation selector switches to the position marked "External modulation." In this condition, the signal generated by the transmitter will be modulated only by the external modulating voltage and may be used to simulate a broadcast station, for example, should it be desired to instruct radio direction finding by means of broadcast stations. Noise or external modulation to be applied as modulation voltages are connected to the desk junction box. The connections are as follows: Right noise selector switch position 1 connects terminal No. 40 in the desk junction box; right noise selector position 2 connects to terminal No. 39 in the desk

junction box; left noise selector position 1 connects to terminal No. 38 in the desk junction box; left noise selector position 2 connects to terminal No. 37 in the desk junction box.

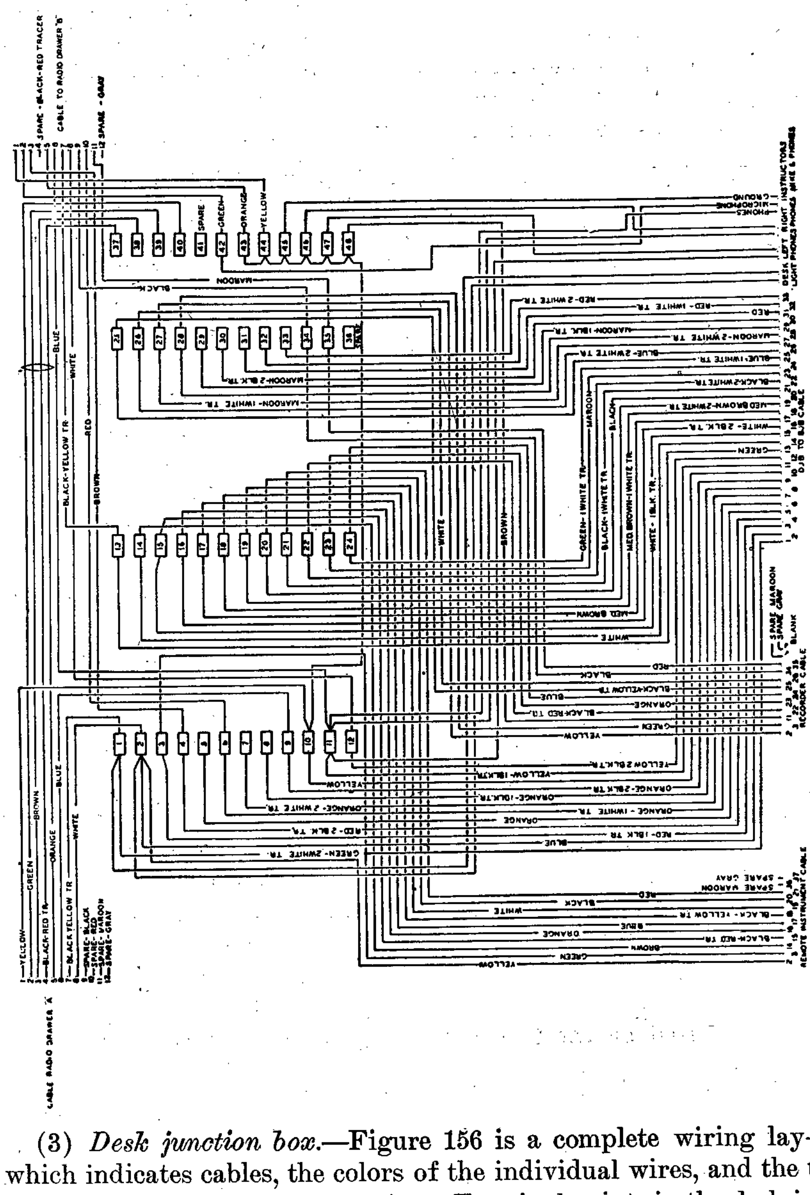


FIGURE 156.—Desk junction box wiring, C–5.

(3) *Desk junction box.*—Figure 156 is a complete wiring lay-out which indicates cables, the colors of the individual wires, and the terminal points in their exact location. Terminal points in the desk junction box are numbered from 1 to 48, point No. 1 being in the upper left-

hand corner, point 12 being the last terminal point directly below 1. Terminal No. 48 is in the lower right-hand corner. The desk junction box serves to connect and interconnect all desk wiring with the trainer, and the connection between the desk and the trainer is made with a 33 wire cable, part No. 10308. Radio cable, marked cable "A", is in the upper right-hand corner of the box when viewing the box from the position in which the instructor sits. Cable "B" is in the upper left-hand side of the box when looking from the direction of the instructor's position. The lay-out of cables along the bottom of the box is

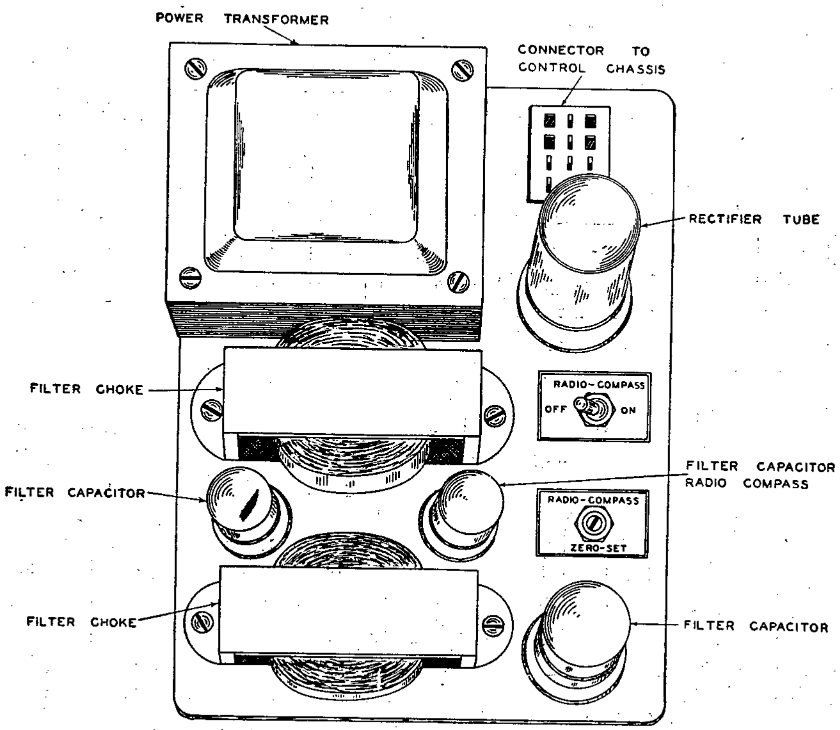


FIGURE 157.—Desk power supply, C-5 radio.

the same in the diagram as it is in the actual lay-out of the box. A large number of spare wires are provided in each cable to accommodate any future additions of equipment that might be deemed necessary.

(4) *Desk power supply C-5 radio.*—The desk power supply (fig. 157) for the C-5 radio is located in the rear left-hand corner of the knee space drawer in the instructor's desk. Its function is to supply the high voltage to the radio transmitters and the control chassis as well as relay and microphone operating voltages and the voltage for

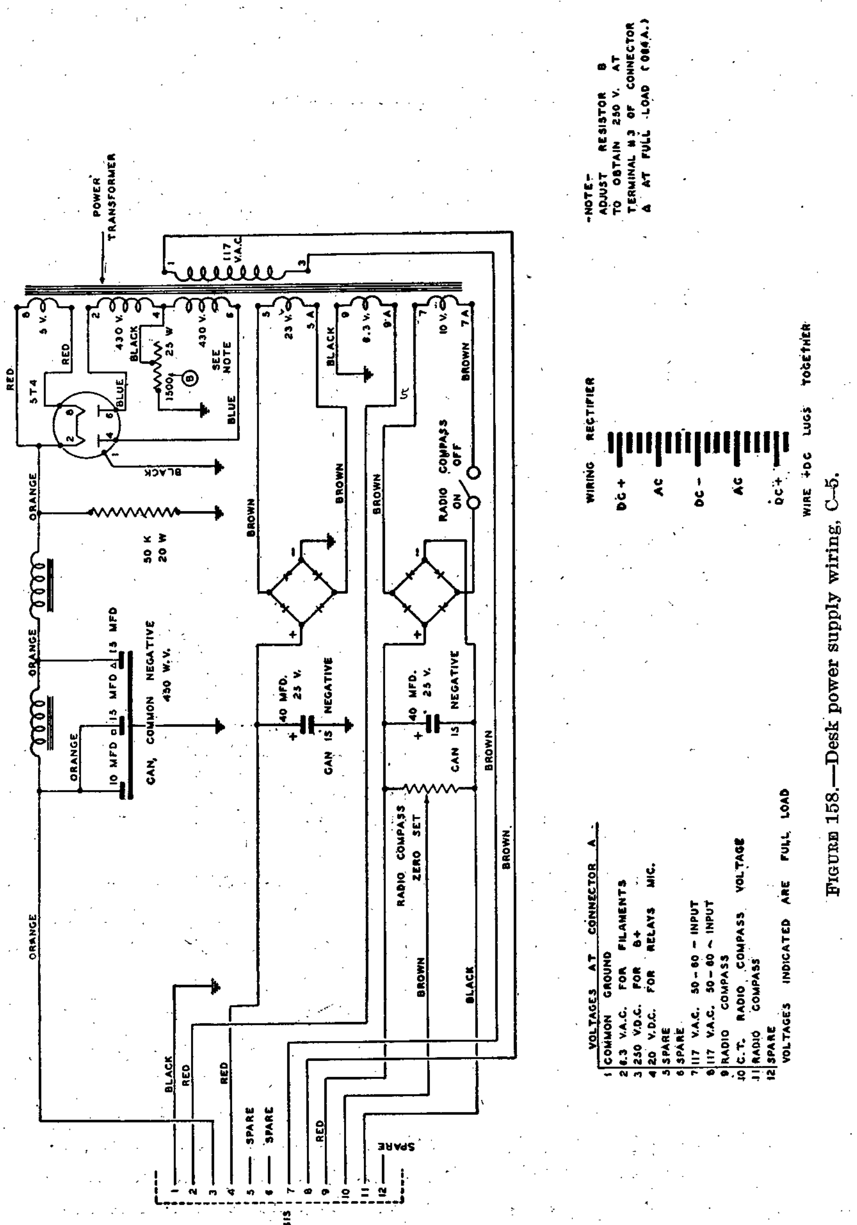


FIGURE 158.—Desk power supply wiring, C-5.

the left-right radio compass. The voltages that should appear throughout the power supply are indicated in figure 158. Figure 58 shows the location of parts with part numbers. The radio compass on-off switch and the radio compass zero set control are mounted on the desk power supply.

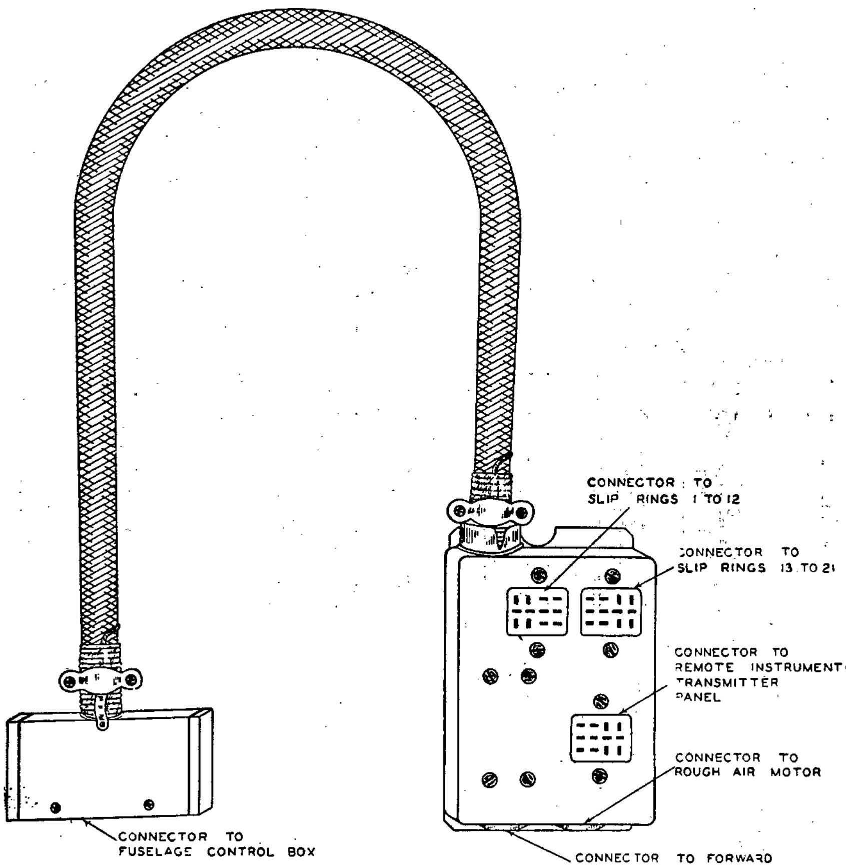


FIGURE 159.—Fuselage intercommunication box, C–5.

(5) *Fuselage.*—The interconnector box located on the floor of the trainer adjacent to the main manifold elbow is the junction point between the wires from the slip ring, the cable to the fuselage control box, the cable to the remote instrument transmitters, the cable to the rough air motor and the cable to the forward ventilating fan. The connection points of the various cables to this box are indicated in figure 159.

(6) *Fuselage power supply C–5 radio.*—The fuselage power supply (fig. 160) is mounted directly under the remote instrument transmitters behind the pilot's seat in the fuselage of the trainer. Its function is to supply all operating voltage for radio, interphone, relay, microphone, and lighting within the trainer fuselage. For the radio and interphone amplifier, high voltage is supplied by the high voltage transformer rectifier and filter system. The output of this high voltage rectifier filter system is 250 volts at approximately 75 milliammeters. This voltage may be adjusted to within close limits with resistor (B), on figure 161. On the lighting transformer, windings are provided for rim light voltage 3 volts a-c; cockpit light, and azimuth scale lamp voltage, 12 volts a-c; and in conjunction with a

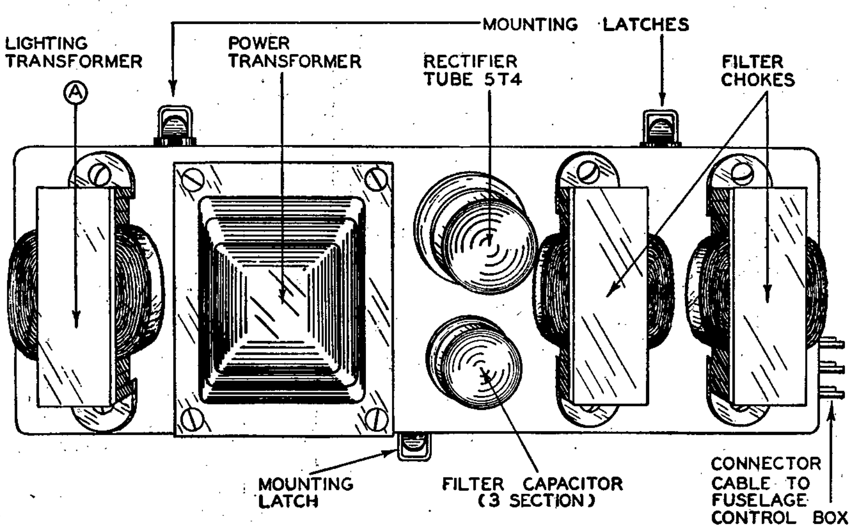


FIGURE 160.—Fuselage power supply, C–5 radio.

small copper oxide rectifier and filter capacitor, the voltages for the "E" relay, microphone, and the compass deflector coil. The fuselage power supply is mounted upon the fuselage power supply mounting panel by means of three latches. Upon installing or removing the power supply from the trainer, it is best to engage or disengage the bottom latch first and the two upper latches last. All values of component parts and part numbers for this supply are found on figure 158. For a lay-out of parts refer to figure 157.

(7) *Radio receiver.*—Mounted on the instrument panel in the trainer fuselage is a standard aircraft receiver which is provided with a tuning control with which the receiver may be tuned from 200 to 400 kc, a volume control and a switch which connects the input circuits

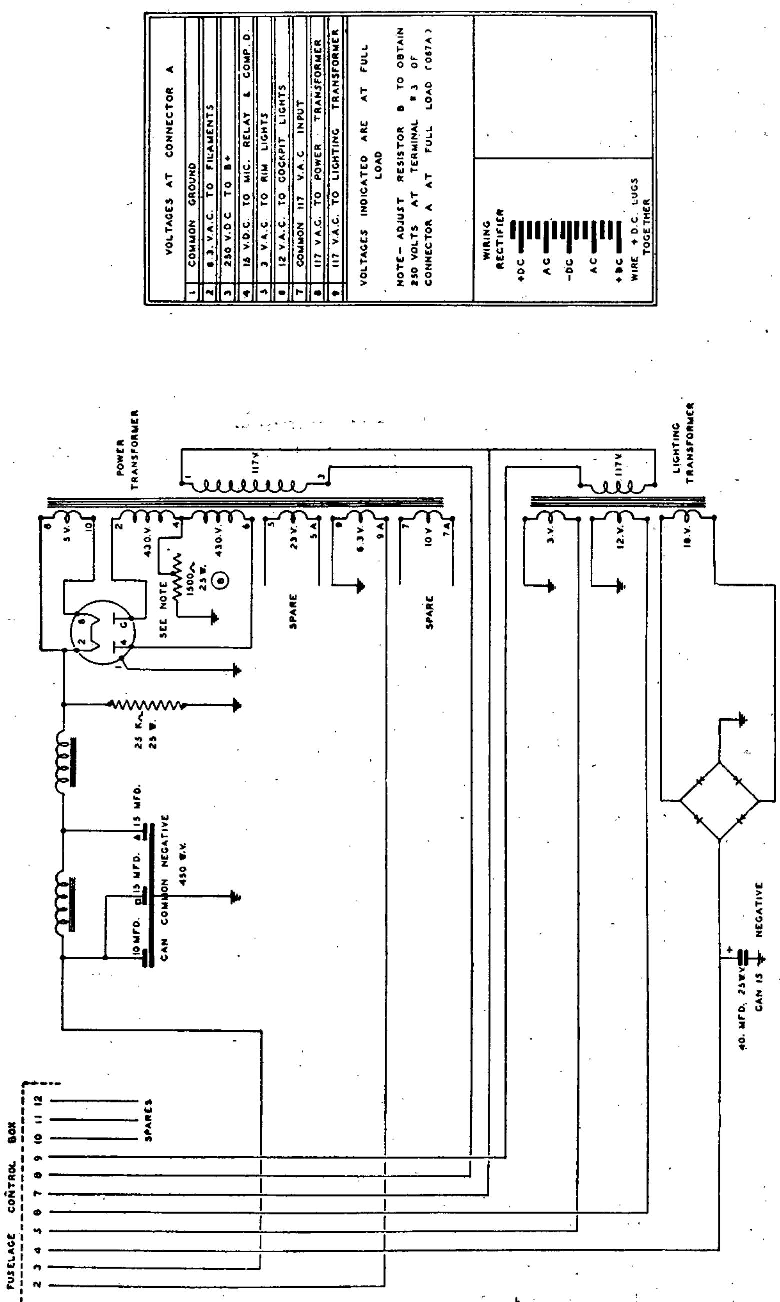


FIGURE 161.—Fuselage power supply wiring, C-5.

of the receiver to either the loop antenna for direction finding purposes or to the omnidirectional antenna for nondirection finding use. See figure 162 for wiring.

(8) *Service and adjustments.*—(*a*) *General.*

1. The service of the radio system used in the C–5 trainers should be the same as that accorded to any piece of high grade communication equipment. A complete set of wiring diagrams is supplied with each trainer instruction book together with drawings indicating the location of various components. It is recommended that a careful study be made of all diagrams and lay-out drawings of the equipment before any repairs or adjustments are attempted. It is recommended that before attempts are made to repair or adjust the radio equipment, the general diagrams such as the interwiring diagram, the slip ring wiring diagram, and the radio system diagram be studied first to acquaint the service man with a general outline of the system and equipment before he attempts repair of any specific part.

2. Further detailed instructions for each specific unit should be studied carefully to determine whether or not the instrument is functioning normally. Sudden changes or departures from normal operating conditions that may occur should, however, be investigated promptly. All components and almost all of the circuits are normal and conventional and no great difficulty is anticipated in maintenance of this equipment by a fully capable and competent radioman. It is urgently recommended, however, that the service and adjustment of the trainer be carried out by someone familiar with the trainer radio system, or if such a person is not available, by a competent radioman in the presence of someone who is familiar with the normal operation of the trainer radio system. Haphazard repairs or adjustments without the use of a complete set of diagrams or proper tools or by untrained personnel are to be discouraged. In general service should be subdivided as follows:

First—visual inspection.
Second—electrical and mechanical check.
Third—repair.
Fourth—recheck and final test.

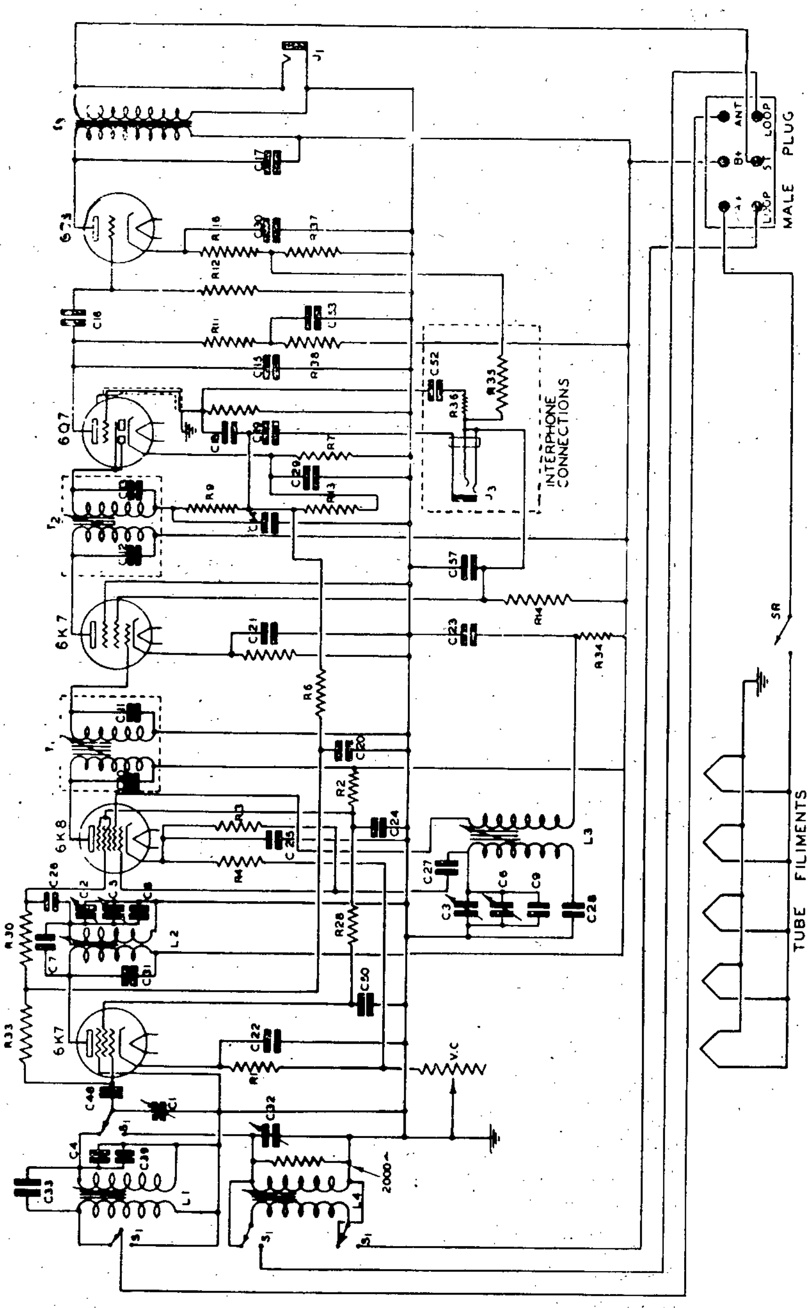


FIGURE 162.—Receiver wiring diagram AMRL-12, C-5 trainer.

3. For visual inspection, unit should be removed and inspected both on up side or top side and under side for damaged or burned components, loose wires, connections, or mechanically deformed parts. If a visual inspection reveals no information, the service man should continue with electrical tests. This is usually performed with a voltmeter, ohmmeter, or similar apparatus, having at hand at all times a wiring diagram and whatever additional information may be helpful for reference. Preceding this, however, the tubes should first be removed, wiped clean, and then checked. It is essential that service work on equipment using electronic tubes be done in this manner because a defective tube may cause a condition which would make it appear that there were several things very seriously wrong throughout the entire piece of equipment, whereas it is actually but one tube. If the tube checker is not available, it is recommended that a complete set of tubes known to be in good operating condition replace the set of tubes in the instrument and that a check be made to see if this cures the difficulty. Failing this, the service man should make an actual test with the voltmeter and ohmmeter. This step will usually reveal the nature of the fault and then steps should be taken to determine whether the unit under test is at fault or whether its condition may be caused by some unit to which it is interconnected. Having definitely established the location of the fault, the next step is repair. Almost all of the parts used in the C–5 radio are commercially available. Reference should be made to the wiring diagram for the size and capacity of the component before replacement is made.

4. All repairs and replacements should be made with due care. Several parts of the C–5 radio by their nature are necessarily crowded and compact. In replacing parts under these conditions, extreme care must be exercised not to damage an adjacent part while repairing another part. Particular care should be exercised in crowded quarters not to burn the insulation on the wires with a soldering iron while soldering a connection. All repairs should be made neatly and securely to obviate the necessity of reservicing a part because of the fact that the original job was not carefully done. Final checks should be made

with a voltmeter or ohmmeter to determine whether or not the circuits remain unchanged. The unit should then be reinstalled in its proper place and the performance of the system checked by someone familiar with the correct performance. Any difficulty encountered in the service of the radio system for the trainer which is not readily corrected should be referred to the Service Department at the factory for further information.

(*b*) *Control chassis.*—In the event of failure of any part or parts of the system, it is recommended that first the tubes should be removed and checked. Any tube that checks within plus or minus 10 percent of normal may be used. Relays are to be afforded the same type of maintenance as is afforded any relay. It has been found that the relays used in the C-5 control chassis, if stored unoperated for long periods of time, will suffer from contact oxidation. Before any attempt is made at repair of a relay, however, the relay should be carefully inspected for mechanical distortion, making sure that the contact springs actually close. If they appear to close mechanically but not electrically the contacts may be cleaned. Because of the small surface area of contacts and the small amount of contact material contained in them, the cleaning of contacts should be done carefully. It is essential that no grade of abrasive coarser than crocus cloth be used in the cleaning of relay contacts. Using a coarser grade than crocus cloth is likely to damage the relay to such an extent that it may not be repaired.

(*c*) *Adjustments of beam shift and beam shift centering controls.*—

1. Beam shift centering controls are to be adjusted in the following manner: Turn the trainer radio system on, tune the receiver to the transmitter to which the beam shift connects, put the modulation selector switch of that transmitter to range position and set the beam shift control on the on-course position which is zero on the dial.

2. At this position a steady on-course signal should be heard. If this does not occur, the beam shift compensator (see fig. 58 for location near keyer) should be set with a screw driver to give the required on-course signal. Should it be found impossible to bring the on-course signal to on-course with the beam shift centering control, the beam shift control itself should be disconnected from the circuit and tested separately. If found defective, it should be replaced with a new unit.

(*d*) *Service and adjustment of transmitters.*—Any failure of transmitter operation should first be checked by removing the tube and checking it or replacing it with a tube known to be in operating condition. Should the fault appear that a carrier is heard but no modulation in any position of the modulation selector switch, the difficulty may also lie in the control chassis. Modulation voltages may be measured directly at the control grid cap of the 6K8 oscillator tube. This voltage should be between 15 and 21 volts when the transmitter volume control is on the full volume position. Following the replacement of a tube in one of the transmitters, it may be noticed that the transmitter frequency dial is no longer true in calibration. Should this be found, proceed as follows: Turn the radio system on, tune the receiver to 400 kc, set the transmitter dial to 400 kc and by means of a screw driver, adjust the trimmer condensers C–4 located on the left side of the transmitters. Should it be found that the replacement of a tube has varied the spot tuning frequency of 278 kc, proceed as follows to rectify this condition: Turn the system on, tune the radio receiver to 278 kc. A spot marked on the dial indicates this precise frequency. Set the modulation selector switch at control tower position and with a screw driver adjust condensers C–6 until maximum amounts is heard in the headphones. These adjustments may be made by one man without assistance as the output of the radio receiver is heard at all times by the instructor at the desk.

(*e*) *The trainer receiver.*

1. The AMRL–12 (fig. 162) receiver employs a total of five tubes in a superheterodyne circuit. Tubes of metal series are used and their function is as follows: 6K7 as radio frequency amplifier, 6K8 as combined first detector and oscillator, 6K7 as intermediate frequency amplifier, 6Q7 as combined second detector and first audio amplifier, and 6J5 as an audio out-put stage.

2. The antenna is coupled to the grid of the 6K7 radio frequency amplifier through a transformer having a high impedance primary. After being amplified in the first stage the signal is coupled to the grid of the 6K8 detector tube where it is mixed with the local oscillator signal.

3. The local oscillator is adjusted so that its frequency is always 90 kilocycles higher than the incoming signal. In the plate circuit of the detector, there will be found not only the original signal frequencies from the antenna and the local oscillator, but also the sum and difference frequencies of these two. However, since the circuits

of the 6K7 intermediate frequency amplifier are tuned only to the difference frequency of 90 kilocycles, only this frequency will be amplified while the others will be discriminated against. This intermediate frequency is fed, in turn, through a diode transformer to the 6Q7 second detector where the signal is demodulated, audio voltages appearing across resistor R8. The audio signal, after being amplified in the triode portion of the 6Q7 tube, is coupled to the grid of the 6J5 out-put tube. The plate circuit of the out-put tube contains a transformer which matches the impedance of the headphones to the plate of the out-put tube. Temperature compensating capacitors are used where necessary to obtain a high degree of frequency stability.

4. Electrical specifications, AMRL-12 receiver:

Intermediate frequency	90 kc.
Frequency range	200–400 kc.
Sensitivity	3 microvolts for 50 milliwatts output.
Signal to noise radio	4 to 1 in power.
Overall selectivity	2 kc at 2 DB. 12 kc at 60 DB.
Power output—undistorted	300 milliwatts
Power output—maximum	500 milliwatts

Overall selectivity is ample to give 3 kc separation between range stations.

5. Service data.

(a) The receiver has been completely tested and alined before leaving the factory and no trimmer adjustments should be made until everything else has been thoroughly checked. If this is found necessary, adjustment should be in accordance with *6* below.

(b) If the receiver fails to function properly, the first thing to check is the tubes. A spare set of tubes should always be kept on hand so as to check difficulty from this source. The tubes should be replaced one at a time, and if this does not clear up the trouble, the following items should be checked:

(c) If the receiver noise seems normal but no signals are picked up, or very weakly, check antenna and

ground connections to see that they are properly connected. The antenna circuits are connected to the receiver through a four-pole plug and socket located on the instrument panel above the receiver.

(d) If the receiver fails to operate after checking the above, remove the cover over the terminal board attached to rear of dust cover. Reference to figure 162 will show the power and antenna connections brought out to a terminal board marked "Male plug" on the schematic. The normal voltage at terminal "A" will be 6.3 volts a-c. The normal voltage at terminal "B" will be 250 volts d-c. In both cases these voltages are measured with respect to the grounded chassis case. When removing the terminal board cover it will be necessary to temporarily reinstall the flexible ground lead under one of the cover screws to complete the grounded side of the circuit. Failure to do so will leave the receiver ungrounded and it will be impossible to obtain correct voltage readings. The above voltage checks are made with the radio switch in the "on" position.

(e) Should the above voltages appear to be normal, then it may be assumed that the difficulty lies within the chassis itself. To check individual voltages on the various tube sockets it will be necessary to remove the cable connector from the rear of the dust cover *after* turning off the trainer master switch.

6 *Alinement instructions.*

(a) The AMRL—12 receiver has been completely alined at the factory and all adjustments sealed. Under normal service conditions, realinement will not be necessary. However, after the receiver has been thoroughly checked and it has definitely been ascertained that the receiver needs to be returned, it should be returned to the nearest depot. It will be necessary to return the receiver loop with the receiver unless a loop with similar characteristics is available at the depot. In addition, a source of power must be supplied before alinement can proceed. The power source should supply 6.3 volts

a-c and 250 volts d-c at 35 ma. drain. The alinement should proceed in the following manner:

(*1*) Connect output of stable signal generator through a .5 mfd condenser to the grid of the 6K8. Short the oscillator circuit with a .5 mfd condenser, (across the C3 section of the gang condenser).

(*2*) Adjust the signal generator to 90 kc and aline I. F. transformers T1 and T2 for maximum output.

(*3*) Remove shorting condenser from gang condenser and connect signal generator to "Ant." post through a 70M mfd condenser.

(*4*) With a signal generator and receiver dial at 210 kc, adjust the cores in oscillator coil, L3; R. F. coil L2; and the antenna coil L1 for maximum output.

(*5*) With the signal generator and receiver dial at 380 kc, adjust the oscillator trimmer C6; R. F. trimmer; and antenna trimmer C4 for maximum output.

(*6*) Repeat operations 4 and 5 above until the trimmer adjustment and the high frequency end no longer affect the adjustment of the cores at the low frequency end of the dial.

NOTE.—The above adjustments are made with the antenna switch in the "antenna only" position.

(b) The loops should be alined as follows:

(*1*) Connect loop and turn antenna switch to "Loop reception" position.

(*2*) Adjust signal generator for high output at 210 kc and loosely couple the output signal to the loop by allowing the output lead to lie near the loop.

(*3*) Adjust the core of the loop transformer L4 for maximum output with the receiver tuned to 210 kc.

(*4*) Adjust the loop trimmer C32 for maximum output after tuning both signal generator and receiver to 380 kc.

(*5*) Repeat operations 3 and 4 above until one no longer affects the other.

48. Cords and plugs.—*a.* The various electrical component parts are interconnected by a system of cords and plugs in order to facilitate the isolation of various circuits and to present a neat, systematic installation.

b. Different trainer models utilize different types of plugs for connection to the units and junction boxes. One type, the Jones plug, is shown in cutaway in figure 163. A complete cording diagram for the C-5 trainer is shown in figure 164.

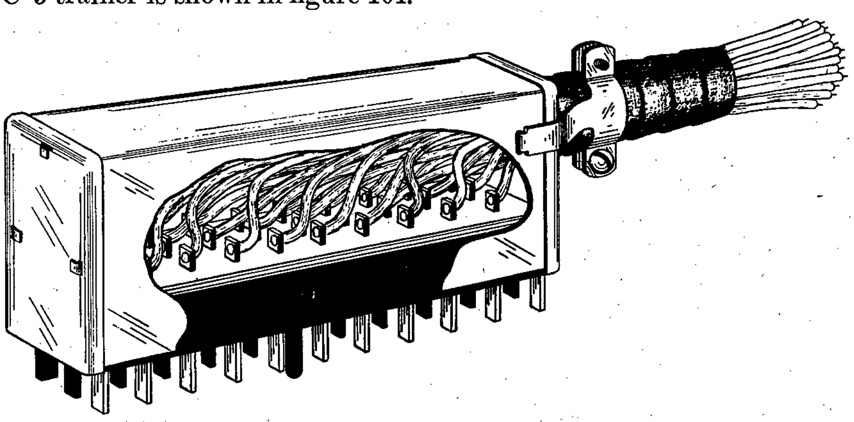


FIGURE 163.—Jones plug (33 contact).

49. Lights.—*a. Instrument side lights.*—For all trainers use 12-volt, 6 cp. double contact bulbs. Current is obtained from the 110-volt, 12-volt transformer, located in the control box in the trainer cockpit. Should it be necessary to trace the wires, it should be remembered that the current for the left-hand light is conducted into the door through the door hinges.

b. Fluorescent light, C-3.—Fluorescent light is used to activate the luminous dials of the instruments. A power supply of 110 volts for each lamp is obtained from two transformers located in the bottom of the cockpit control box. Bulbs for these lamps are the 4-watt size. Should it be necessary to change the lamps or remove them for any reason, dismantle the lamp assembly by pulling the bakelite case from the base, as shown in figure 165. To remove, pull the bulb out of the clip fasteners (A) on each end of the bulb. When removing, it is necessary to unsnap the bottom clip first. Insert new bulb with

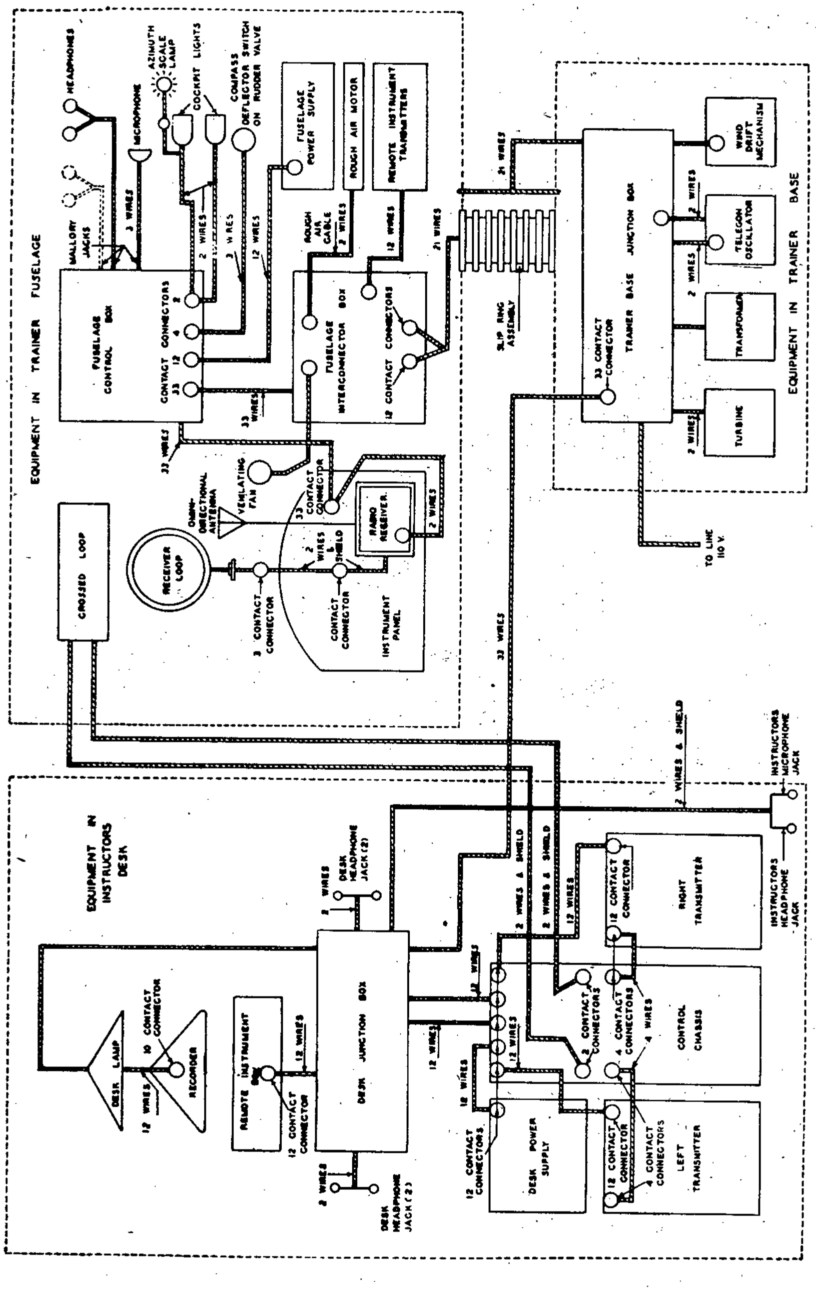


FIGURE 164.—Cording diagram, C-5.

the flat surface flush with the metal receptacle in the reverse procedure. All lights of this type must have a starter (B) in order to actuate the light. The function of the starter is to actuate a filament in the bulb which ionizes the gas, and as soon as the gas is ionized, the starter unit and filament automatically shut off. If the light fails to actuate, malfunctioning of either the bulb or starter may be the source of trouble, in which case both must be individually tested. In case it is necessary to replace the starter unit, completely dismantle the lamp down to the base and disconnect the wiring by removing plug (C). The starter unit may now be removed with a blunt instrument by pushing it out of the base. When installing a new unit, it

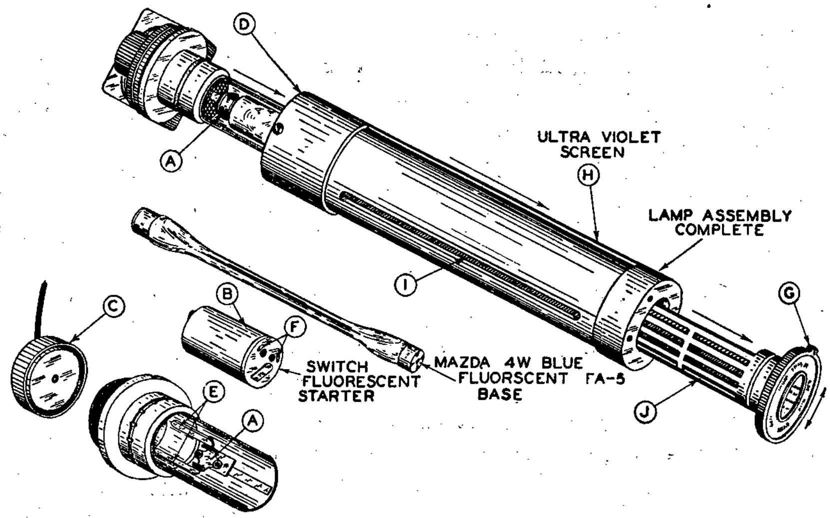


FIGURE 165.—Fluorescent lamp, C-3.

may be necessary to lift up slightly on the prongs (E) to engage in slots (F) to make contact. Reconnect wiring and test for proper actuation of the light. The amount of light is governed by a shutter control (G) located on the top of each lamp. By rotating this unit, the amount of the intensity of the light can be controlled. There is also another control for daylight or ultraviolet light and this is accomplished by moving or rotating the case (D). Ultraviolet lighting is acomplished by a violet screen (H), built into the case, while the daylight effect is obtained through slot (I). ***Caution:*** When dismantling or reassembling the lamp, be careful not to damage the shutters or the case. The shutter is made of bakelite and will break easily.

c. Instrument rim lights, C–5.—All instruments are provided with individual 3-volt, a-c lamps provided by the transformer on the fuselage power pack with the light intensity controlled from the fuselage control box. The azimuth light for the radio compass scale is 12 volts and obtains its supply from different windings from the same transformer as do the rim lights.

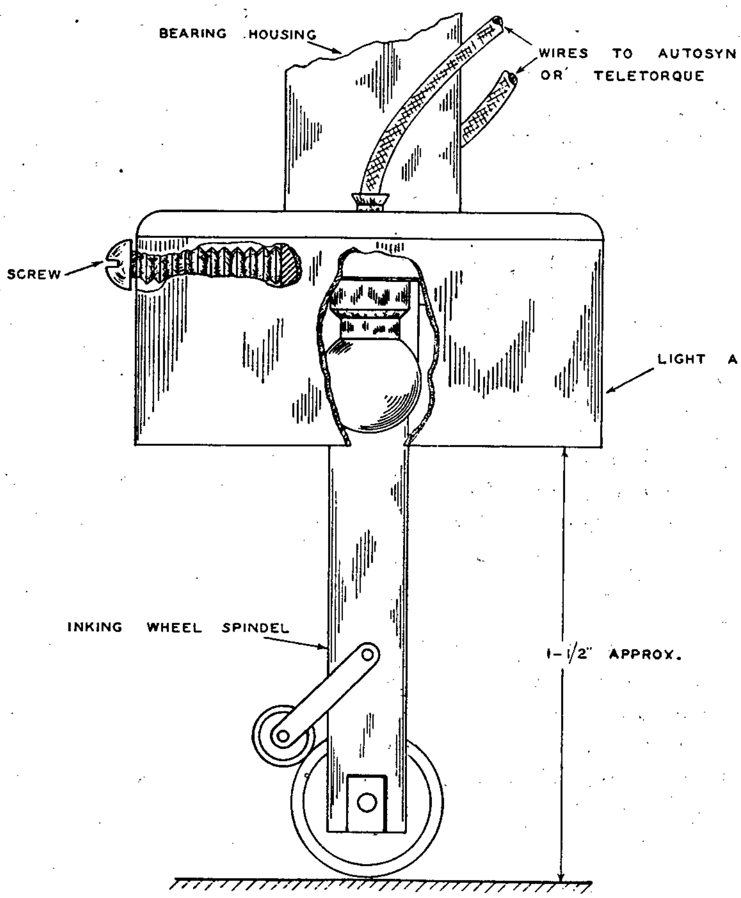


FIGURE 166.—Recorder lights.

d. Recorder lights.—The recorder light uses two 25-volt, .2 ampere, single-contact bulbs. These bulbs are in series and obtain power from the 32-volt terminals (marked "A" and "G") on the recorder teletorque motor. (See fig. 166.) Since these bulbs are in series, one bulb will not light if the other is burned out. Any break in the circuit will shut off both lights. The recorder light assembly is held

in place by a friction spring or setscrew and will slide up or down, to suit the convenience of the instructor.

50. Trainer locking (leveling) devices.—*a.* Two separate devices are provided with which to lock the trainer in a level position, when it is not in use or when adjustments are being made, on C-5 and C-3 models. Earlier models utilized only the system which consists of two simple straps as illustrated in figure 167. The other system consists of a hydraulic jack operating a lever arm which in turn pulls four cables attached to four points on the octagon to pull the fuselage to a level position and hold it there. (See fig. 167.) The first system (lock straps) is used primarily for making adjustments within the trainer fuselage where the "locked level floating" position is used. When the lock straps are thus being used, the other system must be released.

b. When the hydraulic system is being used, the lock straps are swung aside against their stops out of the way. The hydraulic device is designed so that it can be operated either by the student sitting in the trainer cockpit or by the instructor standing outside on the floor. To release the fuselage ready for flight, partially open the valve (A), (fig. 167). To relevel the trainer at the end of the flight see that the above valve is closed and pump the handle. The trainer main switch (ignition switch) may be turned on or off either before or after locking or unlocking the trainer with the hydraulic leveler. However, if the trainer is still running while being leveled, it should be flown to a nearly level position instead of forcing the hydraulic jack and the cables to overcome the pull of the main bellows.

c. Referring to figure 167, it will be seen that the lower end of each of the four cables goes to a drum on the octagon. When the hydraulic jack is released all four cables tend to slacken and sufficient slack must be provided to permit the trainer to bank or nose up and down through the full range of its travel. In order that the cables do not kink or become entangled during this process, the drum (B), (fig. 167) was provided. When the trainer is locked level with the jack pumped up to its top position, the cables are taut and the pulleys are held against the stop (C), (fig. 167). Note that a strong coil spring is attached to this pulley. When the jack is released, the cables slacken. This coil spring turns the drum and winds up, or reels in, the slack in the cable. The spring is sufficiently strong to maintain proper tension on the cable at all times during operation, and yet permits the fuselage to be fully banked or fully nosed up or down, the drums at all times maintaining the tautness in the cable.

d. When the hydraulic jack is operated to again level the trainer fuselage, the cables are pulled until the drums, against the tension

of the coiled spring, have been turned against the stop (C). When the drums have reached this point and can turn no further, continued pumping on the jack and further pull on the cables brings the trainer to its level position. Deflectors are used at each drum to prevent the trainer skirt from fouling the cables and drums.

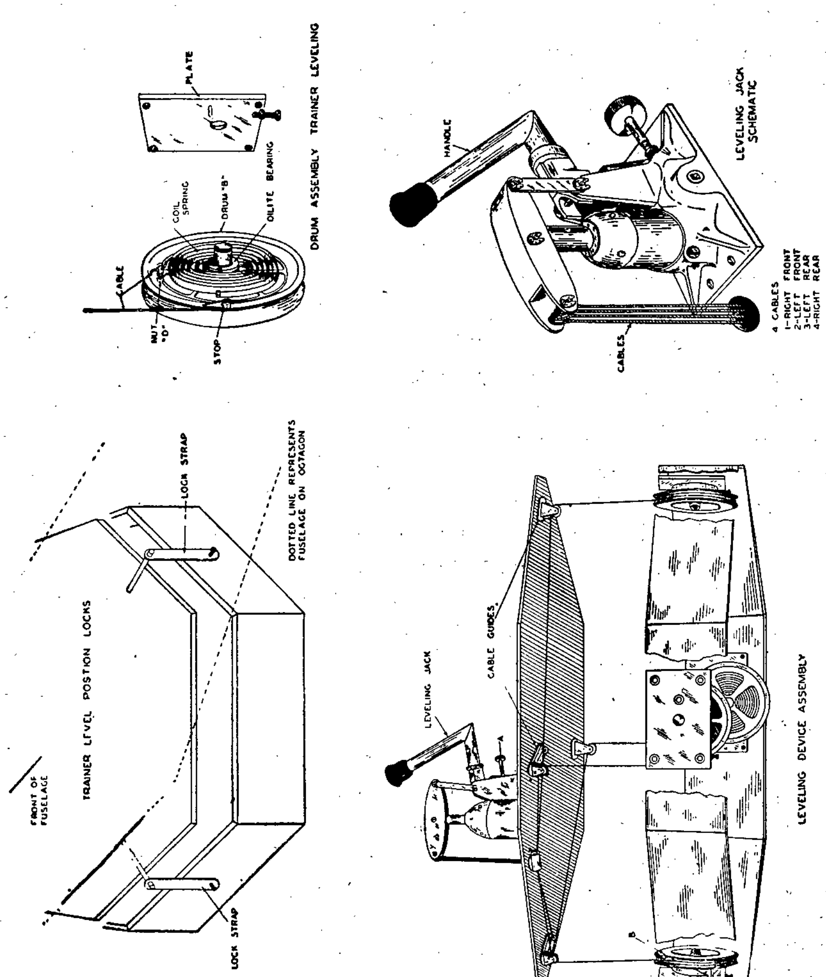


FIGURE 167.—Locking, leveling device.

e. The only adjustment which might be required (and this is very seldom) is the tension of the cables. If, after the trainer has been used for some time, there should be too much slack in the cables so that the fuselage is excessively wobbly while students are climbing in or out, a little slack should be taken out of the cables. Attach side straps to lock pins on fuselage and open partially the valve (A), (fig. 167),

on bottom of hydraulic jack and allow cables to become slack. The cable that was slack can now be tightened a bit by loosening nut (D) and pulling cable through a bit. Tighten nut (D). Close valve (A) and jack up until cables are tight. Lock pins on fuselage should be even with holes on lock straps when they are swung up in place. If the lock pins are not even with the lock straps, loosen nut (E) one or two turns. Ordinarily this should be done equally on all four drums. When this last adjustment is being made to cables, it is *highly important that the hydraulic jack be pumped all of the way to its top position.* Otherwise the cables may be shortened too much and cause damage later when the jack is pumped to the top.

f. Ordinarily no lubrication should be required other than perhaps a slight film of oil on the cables every month or so to prevent rust. The small pulleys and the large drums operate on oilite (oil impregnated) bearings. The jack itself has a built-in reservoir which for normal operation conditions should seldom, if ever, be necessary to fill. If through the development of a leak, or from having been tampered with, the fluid should be lost, it should be replaced with a good grade of light oil of about SAE No. 20. In order to completely eliminate air bubbles from the jack, this filling operation, when and if necessary, must be done with the jack completely submerged in a container of oil. This should be done with the plunger withdrawn within the jack (in its down position.)

Section V

INSPECTION AND MAINTENANCE

Paragraph

51. General.—Routine maintenance of the trainer and associated equipment is not difficult nor does it take excessive time, if done systematically and regularly as stipulated by Air Corps Circular 15-47 and W. D., A. C. Form No. 47. The regularity of the inspection periods is paramount and if the inspection is performed systematically and thoroughly by a trained technician the equipment will last much longer and be easily maintained in perfect condition. If the trainer

is not in perfect operating condition, its efficiency as an instructional unit is proportionally decreased.

52. W. D., A. C. Form No. 47.—*a.* Air Corps Circular 15-47 refers to W. D., A. C. Form No. 47 (Instrument Flying Trainer, Operation, Inspection and Maintenance Record) (Fig. 168). This form will be provided with a suitable mounting board immediately adjacent to the trainer and upon completion will be retained on file until such time as it is inspected by a representative of the Inspection Division, Office, Chief of the Army Air Forces, at which time it may be disposed of.

b. The purpose of the form, as its name implies, is to present a complete historical record of the operating time, inspections performed and maintenance necessary for the life of the trainer. The form does not list separately all of the separate units and unit assemblies of the trainer which require inspection and maintenance on the stipulated inspection periods, but list general categories under which any unit in the trainer may be relegated. With reference to figure 168, the following explanation of the form may be more readily understood and followed:

(1) Heading: Enter the trainer type, C-2, C-3, C-4, or C-5, Army Air Forces No., station, and organization to which the trainer is assigned in the space provided.

(2) Enter the names of the mechanic in charge of the trainer and his assistants with the initial they will use in accomplishing the form in the spaces provided.

(3) Inspection symbols for entry by the mechanic in charge and his assistants in columns 4 to 45 inclusive and column 47.

(*a*) *Black last name initial* or the initial assigned to the individual mechanic, indicating that the part or parts indicated in that column were "Inspected and found satisfactory".

(*b*) *Red Diagonal* (/) indicating that the part or parts were "Inspected and found unsatisfactory".

(*c*) *Black last name initial superimposed on a red diagonal means* "Defect corrected".

(*d*) *Red dash* indicates "Required inspection due but not performed at the time stipulated".

(*e*) A *vertical black line* drawn through the complete column or columns indicates that that column is not applicable to the type trainer the form serves.

NOTE.—If any symbol is used other than the black last name initial a complete explanation of the reason for the symbol used will be printed in the "Remarks" column No. 46.

WAR DEPARTMENT
AIR CORPS
FORM NO. 47
APPROVED MAY 8, 1941

INSTRUMENT FLYING TRAINER
OPERATION, INSPECTION AND MAINTENANCE RECORD
HANDBOOK OF INSTRUCTIONS - T.O. 05-5-16

TRAINER TYPE C-4 AIR CORPS NO. 40-44 STATION Chanute Field ORGANIZATION Link Trainer Instructors School

MECHANIC IN CHARGE Corp. J. Doe (D)
ASSISTANTS Pfc. G. Helm (H) Pfc. D. Dodge (B)

INSPECTION SYMBOLS
FOR ENTRY IN COLUMNS NOS. 4 TO 45 INCLUSIVE AND COLUMN 47
BLACK LAST NAME INITIAL "INSPECTED & FOUND SATISFACTORY"
RED DIAGONAL / "INSPECTED & FOUND UNSATISFACTORY"
BLACK LAST NAME INITIAL SUPERIMPOSED ON A RED DIAGONAL "DEFECT CORRECTED"
RED DASH — INDICATES "INSPECTION DUE BUT NOT MADE"

WEEKLY INSPECTION: Friday
MONTHLY INSPECTION: November 28, 1941
500 HOUR INSPECTION: HOURS NEXT

OPERATED, INSPECTED, OR REPAIRED DATE (1)	TIME: TO-DAY (2)	TIME: TOTAL FOR LIFE OF TRAINER (3)	TURNING MOTOR (4)	INSTRUMENTS (5)	BELLOWS (6)	LOW-WING TURNING (7)	CONTROLS-OPERATION (8)	THROTTLE ADJUSTMENT (9)	COMMUNICATIONS (10)	REMARKS — PRECEDE EACH REMARK WITH THE NUMBER TO WHICH IT PERTAINS (46)	SYMBOL - STATUS TODAY (47)
11-14-41	6:25	300:25	D	D	D	D	D	D	D		D
11-15	5:30	306:55	D	D	D	D	D	D	D	(10) Microphone, Desk, open circuit, cord replaced	D
11-17	8:00	313:55	D	D	D	D	D	D	D	(8) Turning belt stretched, Tightened	D
11-18	7:35	321:20	H	H	H	H	H	H	H		H
11-19	6:40	328:00	H	H	H	H	H	H	H	(8) Turning belt broken, replaced	H
11-21	4:00	332:00	D	D	D	D	D	D	/	(13) Front main bellows worn, patched (10+16) Dry batteries too	/
11-21										low for proper operation, no-new batteries available (17) Turbine	/
11-21										motor brushes replaced (19) Rudder safty link replaced.	/
11-24	7:25	339:25	D	D	D	D	D	D	D	(10+16) New dry batteries installed.	D
11-25	8:00	347:25	D	D	D	D	D	D	D		D
11-26	7:45	355:10	B	B	B	B	B	B	B		B
11-27	6:50	362:00	D	D	D	D	D	D	D	(7) Walking beam P/A. assy. not vertical, adjusted	D
11-28	3:40	365:40	D	D	D	D	D	D	D	(28) Sockets loose, resealed (33) Rudders & Aileron neutralized.	D
11-28										(38) Climb valve leaking at limit valve, repacked.	D
12-1	7:00	372:40	D	/	D	D	D	D	D	(5) Airspeed Transmitter malfunctioning, no replacement.	/
12-2	5:00	377:40	D	/	D	D	D	D	D		/
12-3	6:20	384:00	D	/	D	D	D	D	D	(9) Throttle readjusted	/
12-4	4:15	388:15	D	D	D	D	D	D	/	(5) New Airspeed Transmitter installed (10) VT-50 burned out, replaced	/
12-4										Beam shift control malfunctioning, no replacement.	/
12-5	7:00	395:55	D	D	D	D	D	D	D	(10) Beam shift control replaced (12-25) Weekly inspection not	—
12-5										performed, emergency flying schedule	—
12-6	1:20	397:15	D	D	D	D	D	D	D	(12-25) Inspection performed	D

WEEKLY INSPECTION

DATE	TURNING MOTOR (12)	BELLOWS (13)	FANS AND MOTORS (14)	COLLECTOR RINGS AND BRUSHES (15)	DRY BATTERIES (16)	TURBINE & MOTOR UNIT (17)	COMPASS DEFLECTOR (18)	CONTROLS (19)	LEVERS AND LINKS (20)	FLIGHT RECORDER (21)	MAIN UNIVERSAL JOINT (22)	AIR TRANSFER ELBOW (23)	HOSE CONNECTIONS (24)	CONTROL VALVES (25)
11-14-41	D	D	D	D	D	D	D	D	D	D	D	D	D	D
11-21	D	D	D	D	/	D	D	D	D	D	D	D	D	D
11-24					D									
11-28	D	D	D	D	D	D	D	D	D	D	D	D	D	D
12-5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12-6	D	D	D	D	D	D	D	D	D	D	D	D	D	D

MONTHLY INSPECTION

DATE	BELLOWS HOOKUP SOCKETS (27)	(28)	SPIN TRIP ASSEMBLY (29)	COMPENSATOR UNIVERSAL STUD (30)	TURNING MOTOR GEARS (31)	BELT AND ADJUSTING IDLERS (32)	CONTROLS (33)	SET SCREWS AND BRACKETS (34)	WIRING AND ELECTRICAL CONNECTIONS (35)	ROUGH AIR SIMULATOR (36)	SLIP STREAM SIMULATOR (37)	CLIMB-DIVE VALVES (38)
11-28	D	D	D	D	D	D	D	D	D	D	D	D

500 HOUR INSPECTION: TURBINE AND MOTOR UNIT (41), COMPENSATOR SPRINGS (42), WINGS AND FUSELAGE (43) — no entries.

INSPECTED (48, 49, 50) — no entries.

FIGURE 168.—W. D., A. C. Form No. 47.

(4) In the spaces provided directly below "Weekly inspection" and "Monthly inspection," enter the day of the week and the day of the month, respectively, on which the inspection is to be performed. The weekly inspection is performed on any predetermined day of the week that is convenient for the operating and maintenance personnel. For instance, if the instructional schedule is such that all days are scheduled except perhaps Friday, enter Friday in the "Weekly inspection" block. This day, or at least part of this day, should be set aside for this inspection period each week. The monthly inspection period should be assigned to the last working day of each month coinciding with the day of the week that the weekly inspection is to be performed on so that the monthly inspection may be a continuation of the weekly and daily inspections. Enter the time in hours that the 500-hour inspection period will be due in the space provided.

(5) (*a*) Column 1: Enter the date numerically (as 11-14-41) for the month, day of the month and year, for any day that the trainer was operated, inspected or repaired, in the first space on each new form; for all subsequent dates in this column enter only the month and day of the month that the trainer was operated, inspected, or repaired.

(*b*) Under the "Time" column enter the operating time, of the trainer in hours and minutes (6:25, 300:40) in columns 2 and 3. Column 2 being the total time the trainer was operated for that particular day only. Column 3 being the total time the trainer has been operated since placed in commission inclusive of that dates operating time.

(*c*) Columns 4 to 11 inclusive, under "Daily inspection visual and operation," list the various units and catagories of units that are inspected either by a visual inspection, by operating the trainer, or by the daily flight check. In the spaces provided under each column for that particular day, enter the appropriate symbol that tells the status of that unit or a unit included under one of the general listings for that day, remembering that any column having any symbol other than a black initial appearing in it must be fully but concisely explained in column 46.

(*d*) Columns 12 to 26, under "Weekly inspection," contain the units and general catagory listings of the various assemblies and units that are inspected during the weekly inspection; as a general rule, no symbol should appear in any of these columns at any time except for the date when the weekly inspection is due and performed, is due and not performed, or performed after the date on which it was due.

(*e*) Columns 27 to 40 inclusive are to be utilized in giving the status of the various assemblies to be inspected during a monthly inspection period with the same general rules applying to entries that apply to the columns under the weekly inspection group.

(*f*) Columns 41 to 45 inclusive are reserved for pertinent entries of symbols when performing the 500-hour inspection on the trainer and equipment.

NOTE.—All columns not listing a unit or category of units such as columns 11, 26, and 28 are provided so that any particular unit or assembly not already listed, that the experience of the mechanic in charge has indicated should be listed, may be entered and used. For example, under extremely high operating temperatures it may be necessary to inspect, lubricate, and maintain the turbine and motor unit weekly; such being the case, the turbine and motor unit may be entered in column 26 and be included in the weekly inspection. However, if this is done on the form serving one trainer, it should also be entered on forms serving additional trainers at the same station.

(*g*) Column 46 should contain the printed explanation, preceded by the column number or numbers to which the remark pertains, for any symbol used other than the black last initial. In event the explanation is too long for the single line, the next line below may be used in which case it is necessary to enter the same date in column 1 as the preceding line and place brackets, one on each end of the form, around the two or more lines used.

NOTE.—If a red symbol remains in effect for 2 or more days in the "Status today" column, it is not necessary to enter the explanation for that symbol in the "Remarks" column each day the red symbol is in effect. The original explanation covers the symbol until it is cleared and explained.

(*h*) Column 47 is reserved for the status of the complete trainer for that particular date; symbols used are those previously described. The governing symbol will be entered at the completion of the inspection or maintenance period. The governing symbol is that symbol entered in any column 4 to 45 inclusive. If a single column is left on a diagonal at the completion of the inspection, the status will be a diagonal. If all columns used contain a black initial, the status will be a black initial.

NOTE.—*Under no circumstances* is a red symbol to be erased. The only means of clearing a red symbol is to superimpose a black initial over it.

(*i*) Columns 48, 49, and 50 under "Inspected" are for the purpose of providing spaces where the department head, technical inspector, or higher authority may place his initial after inspecting the equipment and form. If column 48 is utilized by the department head, then "Department head" will be printed in that column.

(*j*) Upon completion of this form it will be filed, as previously directed, only after the entry on the last line of the form has been transcribed in total to the next succeeding form. If the last entry in the "Status today" column is anything but a black initial, the entry in the remarks column which explains that symbol must also be transcribed.

(*k*) When a new trainer is received, set up, and placed in commission, the complete trainer must be thoroughly inspected. Although the manufacturer inspects and tests the completed trainer very thoroughly before shipment, there is always the possibility that some part or parts may have been damaged during shipment. When the trainer is placed in commission, the new Form No. 47 should be instigated with *all* columns showing the status of the various parts as they were received. The "Remarks" column should show an appropriate entry as to its condition when received, where and by whom set up, and any other pertinent information relative to its initial installation.

(*l*) If a trainer is shipped from one Army Air Forces station to another after having been in use, all Forms No. 47, pertinent to that trainer, which have not been inspected by a member of the Inspection Division, Office, Chief of the Army Air Forces, should be shipped with the trainer.

c. Figure 165 is a reproduction of an actual Form No. 47; with reference to it and the following day by day explanation, at least the majority of the possible entries may be more clearly understood.

(1) *11-14-41.*—The daily and weekly inspections were performed by or under the direct supervision of Corporal Doe (D). The inspections were performed at the beginning of the day and all parts were found satisfactory. Six hours and 25 minutes operating time was recorded, representing the total time the trainer was operated the 14th. Since all parts were found to be in satisfactory operating condition after the inspection was completed, even if routine lubrications and small minor adjustments were necessary, the "Status today" column indicates the black initial of Corporal Doe.

NOTE.—This entry of the 14th was the last entry on the preceding completed Form No. 47, and has been transcribed according to directions. No entry in the "Remarks" column is necessary, because the weekly inspection was performed, the symbols appearing in the columns under this heading being sufficient.

(2) *11-15-41.*—Corporal Doe performs the daily inspection and in so doing discovers that the microphone cord at the desk had become open-circuited by a break in one of the conductors and, since

it is in most cases impractical to repair such a break in a conductor of this type, the cord was replaced as indicated in column 46. Column 10 was placed on a diagonal when the communication failure was noticed, but was cleared after the trouble had been localized and rectified. The diagonal was placed in the "Status today" column at the same time it was entered in column 10 but was not cleared until the entire inspection was completed as this diagonal may and does, under some circumstances, indicate that more than one diagonal exists elsewhere on the form for that day. Five hours and 30 minutes was recorded as the total operating time for that day and was added to the 300:25 (total of trainer) raising it to 305:55 for the 15th.

(3) *11-17-41.*—The daily inspection was performed on this Monday morning by Corporal Doe—all parts found satisfactory. Eight hours operating time recorded for the day, bringing total for the life of trainer to 313:55.

(4) *11-18-41.*—Pfc Helm (H) performed the routine inspection with all parts found satisfactory. Seven hours 35 minutes operating time—321:30 total life of trainer.

(5) *11-19-41.*—In performing the daily inspection Pfc Helm found that the turning belt was too loose and had to be tightened. He placed a diagonal in column 8 under Controls–Operation and in the "Status today" column; tightened the belt, cleared column 8 with his initial; completed the inspection and cleared the diagonal in column 47.

(6) *11-21-41.*—Being Friday, with the weekly inspection due, Corporal Doe either performed the necessary maintenance or supervised it with results as indicated—column 10. It was found that the radio compass and the voice circuits of the radio simulating equipment did not have enough voltage applied to them for proper operation, but since no new batteries were available at that time it was necessary to leave the old ones in and to leave columns 10 and 17 on a diagonal. Column 13, a small hole was located in the front pitching bellows, patched and diagonal cleared. Column 17, the brushes of the turbine were found to be worn excessively which required the replacement. Column 19, the rudder bar safety link had been elongated and was nearly broken, necessitating its replacement. Column 47, all trouble located and remedied was explained but, due to the extent of the troubles and space necessary for its explanation, three lines were used and those lines inclosed with brackets at both ends of the form, the date entered on each line and the status today, a red diagonal, since columns 10 and 16 were of necessity left that way, brought forward.

(7) *11-24-41.*—At the beginning of this day, Corporal Doe brought forward the two red diagonals existing in columns 10 and 16, procured new dry cells, made the necessary installation of them, cleared the two diagonals with his initial, completed the daily inspection, and explained in column 46 that the new dry batteries had been installed. Since, for this particular date, all columns were cleared, the red diagonal in column 47, which had been brought forward from the previous date, could be cleared; also indicating that the complete trainer had been inspected and found satisfactory. Seven hours and 25 minutes daily operating time was recorded, to bring the total life of the trainer to 339 : 25.

(8) *11-25-41* and *11-26-41.*—Corporal Doe performed the daily inspection on the 25th and Pfc Dodge on the 26th. All parts were found to be in a satisfactory condition as indicated by the black initials appearing in column 47. Two days operating time, raising the total operating time on the 26th to 355 : 10.

(9) *11-27-41.*—During the daily inspection, visual and operating, Corporal Doe discovered that the walking beam of the pitch action assembly was not vertical, indicated by the fact that the low wing turning (column 7) action was incorrect. The walking beam was adjusted—the diagonal in column 7 and column 47 were cleared.

(10) *11-28-41.*—As indicated in the monthly inspection columns, November 28 was the date previously set as the date for the monthly inspection. This date corresponding with the weekly inspection performed each Friday. This extensive inspection, performed by Corporal Doe or by his assistants under his supervision, was found to be satisfactory except for the Bellows hook-up socket, column 27; Controls, column 33; and the Climb-dive valve assembly, column 38. By referring to column 46, "Remarks," it may be seen that the trouble as indicated by the red diagonal in column 27 was that the sockets were loose which necessitated their resetting. The rudder and aileron controls were not neutralized, and the climb valve was leaking at the limit valve connection. The rudder and aileron were neutralized and the limit valve repacked, placing these units in a serviceable condition; whereon Corporal Doe cleared the diagonals existing in columns 27, 33, 38, and 47. The explanation of the troubles found on this inspection were of sufficient length to necessitate the use of two lines in column 46, whereby it became necessary that these two lines be inclosed in brackets, the second line dated the same as the first, and the symbols appearing in the "Status today" column brought forward. Operating times for the 27th and 28th, 6 : 50 and 3 : 40, respectively, raise the total time for the life of the trainer to 365 : 40.

(11) *12-1-41.*—In performing the daily inspection, Corporal Doe found that the air speed transmitter of the Telegon system was not working properly, whereon he placed column 5, Instruments, on a red diagonal, but found on inspection that the air speed transmitter could not be repaired locally and, since no replacement was available, the malfunctioning unit was not removed, but column 5, as well as 47, was left on a diagonal. The inspection is completed as indicated by the black initials in columns 4, 6, 7, 8, 9, and 10. The malfunctioning of the air speed transmitter did not necessarily throw the complete trainer out of service, as indicated by the 7 hours recorded time for that particular day.

(12) *12-2-41.*—Columns 6 and 47 were left on a red diagonal this date because no replacement had been procured for the air speed transmitter. The remainder of the daily inspection was made and found satisfactory.

(13) *12-3-41.*—In addition to the malfunctioning air speed transmitter, diagonal in column 5, it was found that the throttle was considerably out of adjustment. The throttle was adjusted as indicated by the remarks in column 46 and the black initial appearing on the red diagonal in column 9, columns 5 and 47 still showing a red diagonal by the malfunctioning of the air speed transmitter.

(14) *12-4-41.*—A new air speed transmitter was procured and installed by Corporal Doe on this date, the appropriate remark made in column 46, and the diagonal of column 5 cleared. However, during the inspection it was found that the VT-80, the full wave rectifier of the radio simulating equipment, was bad; also that the beam shift control did not function properly. The VT-80 was replaced, but no spare was available for the beam shift control. This necessitates leaving columns 10 and 47 on the red diagonal. Again on this date two lines in column 46 were utilized with the date and "Status today" symbol brought forward.

(15) *12-5-41.*—Column 10 was cleared by Corporal Doe indicating, as explained in column 46, that the beam shift control had been replaced; however, this being Friday, with the weekly inspection due, columns 12 to 25 have indicated, by the red dash, appearing in each column, that the required inspection was due but not performed. Column 46 explains this red dash as being necessary because of an emergency flying schedule. Again two lines were utilized in column 46, both lines bracketed and dated as previously explained. Since the required inspection was due but not performed, column 46 indicates this fact by the red dashes appearing in both lines for this date.

(16) *12–6–41.*—As indicated by previous dates and schedules, Saturday was not used for the trainer flying schedule and since no flying was scheduled on this date, and the weekly inspection, which was due but not performed on the previous day, was performed by Corporal Doe and his assistants on this Saturday. The red dashes appearing in columns 12 to 25, on the 5th, were brought forward to the line of the 6th and cleared by Corporal Doe's initials as the weekly inspection was performed. The appropriate remark was made in column 46 and the red dash, cleared by a black initial, appears in column 47.

53. Daily inspection.—*a.* Any inspection whether daily, weekly, monthly, or 500-hour must be performed according to some predetermined logical sequence for a number of reasons, the most important of which is to insure that the inspection will be thorough and performed in such manner as will require a minimum amount of time.

b. As an aid in performing the daily inspection a form such as figure 166 or some similar form may be printed locally and used. The form "Daily Inspection" provides a list of things to be done and units to be checked and serviced each day that the trainer has used. Ordinarily the daily inspection, which may be likened to the preflight inspection as performed on all Army Air Forces airplanes at the start of each flying day, is performed the first thing each morning or at the beginning of each schedule of operation for the day.

c. The daily inspections should be divided into three definitely separate parts: the visual inspection which entails, as its name implies, merely a visual check of the various units and assemblies; the operating check performed by the operator removing the trainer seat, turning the trainer on, and operating the controls in such a manner as to actuate the various moving parts of the mechanism to ascertain their working condition; and the flight check whereby the person checking the trainer actually flies the trainer, hood open, and judges by its reactions to the movements of the various controls, mechanical and electrical, its operating condition. The following form (fig. 169) is a step by step outline with explanatory remarks, of the daily inspection; this form, although it may seem lengthy, requires very little time to accomplish. Remember that if the trainer equipment is properly and diligently maintained, discrepancies will always be of a minor nature when they do exist. This daily inspection should be performed (by an experienced and trained man) in a maximum of 20 minutes.

d. Visual inspection.—(1) *Clean the bleed holes.*—With a toothpick or some like device, clean the bleed holes being especially careful not to enlarge them and not to break off bits of wood in them.

INSTRUMENT FLYING TRAINER - DAILY INSPECTION SHEET

FROM ______________ TO ______________ TRAINER NO. ______________

MECHANIC ______________

ASSISTANT ______________

	DATE						
VISUAL INSPECTION:							
1. CLEAN BLEED HOLES							
2. CORDS & PLUGS							
3. LEAVERS & LINKAGES							
4. TURNING MOTOR & BELT							
5. POWER, LIGHTS, & OSCILLATOR							
6. DESK EQUIPMENT							
7. REMOTE INSTRUMENTS							
8. SET CLOCK							
9. ALTIMETER & VERTICAL SPEED							
10. CLEAN TRAINER							
11. HOSES & BELLOWS							
12. HOOK-UP SOCKETS, SCREWS, & NUT							
13.							
OPERATING INSPECTION:							
1. MAIN CONTROL VALVES							
2. FLOAT TRAINER							
3. THROTTLE							
4. TACH. & AIRSPEED							
5. STALL VALVE							
6. SPIN-TRIP ASS'Y. & SPIN VALVE							
7. COMPASS DEFLECTOR							
8. DEVIATION CARD							
9. AUTOMATIC RECORDER							
10. RADIO SIMULATING EQUIPMENT							
11. REMOTE INSTRUMENTS							
12.							
FLIGHT CHECK:							
1. CHECK CONTROLS & OPERATION							
2. SLIP STREAM							
3. NOSE HEAVINESS							
4. SKID OR COAST							
5. AUTO. TURN & AUTO. BANK							
6. TURN & BANK INDICATOR							
7. DIRECTIONAL GYRO							
8. GENERAL FUNCTIONING OF INSTS.							
9. STALL, SPIN, RECOVERY							
10. ROUGH AIR							
11. RADIO SIMULATING EQUIPMENT							
12. TRANSCRIBED TO FORM 47							

FIGURE 169.—Daily inspection sheet

(2) *Cords and plugs.*—Check to see that all cords are in their proper places, unfrayed, and properly protected. See that all plugs serving these cords are seated and making positive contact on all contact points.

(3) *Levers and linkages.*—Check all levers and links to see that they are not binding, that all are keyed, and that no excessive play exists in any of their sockets or connections.

(4) *Turning motor and belt.*—Remove turning motor hood, check visually the hose connections, sliding valves and seats, springs, connecting rods, bellows for leaks, and pinion gears to see that they are tight upon the crankshafts and that they are making proper contact with the main gear. Check belt and belt idlers for cleanliness and belt at its connector.

NOTE.—Be certain that the belt idlers are equidistant from turning motor supporting arms.

(5) *Power, lights, and oscillator.*—Connect the power supply to the trainer and energize lights and oscillator.

(6) *Desk equipment.*—Connect automatic recorder, check visually all connections for the desk radio equipment, the keying mechanism, and general appearance of radio chassis.

(7) *Remote instruments.*—Check visually for broken glass and general appearance of remote instruments and instrument panel.

(8) *Set clock.*—If a clock is utilized at the desk, check to see that it is synchronized with the clock on the trainer instrument panel.

(9) *Altimeter and vertical speed indicator.*—If equipment does not utilize the remote Telegon system set altimeter to at least 500′ below zero and the vertical speed indicator to zero with trainer turned off. If equipped with the remote Telegon system, set both indicators to at least 500′ below zero.

NOTE.—Be sure that both indicators are exactly synchronized as to the indications of altitude and barometric scales.

Energize remote Telegon system by turning on the main and oscillator switches at the base junction box, and with the knurled nut provided on the back of the vertical speed transmitter, adjust the vertical speed to zero indication checking desk instrument to see that it coincides with the trainer instrument.

(10) *Clean trainer.*—With a vacuum sweeper if necessary, or with a dust cloth, clean the equipment inside and out.

(11) *Hose and bellows.*—Check all vacuum hose, bellows, and hose connections for deterioration, loose connections, chafing, and leaks.

(12) *Hook-up sockets, screws, and nuts.*—Check for proper play in bellows hook-up sockets, for loose hold-down screws of these sockets,

and all screws and nuts securing the various assemblies to the component parts.

e. Operating inspection.—(1) *Main control valves.*—With the trainer turned on, locking straps released, check for neutralization of controls and main control valves. Check for proper lubrication of the control valves.

(2) *Float trainer.*—By use of the locking straps, trainer turned on, adjust the controls so that the trainer will be locked level, floating in the straps.

(3) *Throttle.*—Check by moving of the throttle to see that the proper tension is being maintained as friction adjustment. Check to see that there is no lost motion in its linkages with the walking beam of the pitch action assembly and the linkage from the walking beam to the climb-dive valves and lever arms of the air speed and tachometer system. Check the proper vertical speed with the throttle fully open.

(4) *Air speed and tachometer.*—With trainer still floating in locks, check air speed and tachometer for proper indications (fig. 85), throttle set at cruising and throttle closed.

(5) *Stall valve assembly.*—Check stall valve assembly, for time of operation, against indications of the air speed indicator.

(6) *Spin-trip assembly and spin valve.*—Check spin-trip assembly, center bellows, to see that it is actuated (collapsed) when the stall valve is actuated. Check top and bottom bellows, linkages, and movement of its walking beam for proper movement. Check spin valve hose connections, actuating fork, and vents to atmosphere.

(7) *Compass deflector.*—Check compass deflector for time and amount of deflection.

(8) *Deviation card.*—Check deviation card against magnetic compass and octagon markers.

(9) *Automatic recorder.*—Check general operation of automatic recorder against movements of the trainer.

(10) *Radio simulating equipment.*—With the aid of an assistant, if possible, check general functioning of the radio or radio simulating equipment at the desk and in the trainer with trainer running and maneuvering.

(11) *Remote instruments.*—Check remote instrument indications against indications of fuselage instruments for proper synchronization and smoothness of operation. Check vibrator motor on all instrument panels.

f. Flight check.—(1) *Controls and operation.*—Seated in the trainer, hood open, check operation of controls, control valves, turning motor, and main bellows by turning, banking, and pitching action.

(2) *Slip stream simulator.*—Check movements of main controls against tension of slip stream simulators.

(3) *Nose heaviness.*—Check for proper functioning of nose heaviness feature of the rudder valve.

(4) *Skid and coast.*—Check slippage of the main belt for proper amount of coast, trainer locked level laterally, full rudder applied for at least three complete turns, and then full application of opposite rudder.

(5) *Automatic turn with automatic bank.*—Check automatic bank and automatic turn features of the trainer (proper time and amount).

(6) *Turn and bank indicator.*—Check turn indicator for rate of 180° in one minute, and proper indications of the inclinometer.

(7) *Directional gyro.*—Check horizon bar with side indexes to see that it is level when the trainer is level. Check also for smoothness of operation.

(8) *General functioning of instruments.*—Check all instruments, trainer and desk, for general functioning, proper indications, and smoothness of operation.

(9) *Stall, spin, and recovery.*—By maneuvering the trainer into the attitude of a stall and permitting it to go into a spin, both left and right, and by making recovery from a spin, check for time (against air speed indicator) of motion, complete stall, and recovery.

(10) *Rough air.*—Check for proper opening of flap valves of rough air assembly, timing, and operation.

(11) *Radio or radio simulating equipment.*—Recheck for proper functioning of all radio aids to navigation simulated by trainer and desk equipment.

g. To properly accomplish this form, enter the date in the space provided in each column and, by use of the appropriate symbols previously explained in connection with Form No. 47, make the appropriate entries, in the various squares of the column being used, as the check is made. Upon completion of the daily check, transcribe the symbols to the appropriate columns under "Daily inspection" on Form No. 47. The daily inspection sheet may be used to cover a number of days; however, the symbols will be transcribed to Form No. 47 at the end of the daily inspection *each day.* When the form is completely filled it may be disposed of at the discretion of the person in charge of maintenance on the trainers, as all pertinent information has been or should have been transcribed to Form No. 47.

54. Weekly inspection.—*a.* The various units inspected on this period vary little from the units covered on the daily inspection period; however, the inspection is much more thorough in the checks

required and maintenance performed. Since this inspection is broader in scope, necessitating the removal of various units for cleaning and lubrication, it cannot, like the daily inspection, be performed in a matter of minutes, so it is advisable to reserve a half day of each week for this work.

b. If the inspection is performed during the latter part of a day after the trainer has been used (which necessitates a daily inspection with appropriate entries on Form No. 47), a second line for the same date will be used since part of the weekly inspection consists of repeating the daily inspection.

c. Figure 170 is a reproduction of a form similar to the daily inspection sheet which may be used to facilitate the accomplishment of the weekly inspection. Following is a brief outline of the maintenance necessary for this period.

(1) *Turning motor*.—Remove turning motor cover, lubricate slide valves with powdered graphite applied with a damp rag. *Do not use oil or grease on these valves*. Inspect and test bellows for leaks, check ball bearings, clean belt pulleys with carbon tetrachloride or some other suitable cleaner, check all setscrews, brackets, leather or composition nuts on slide valves, hose connections, and test for smooth operation left and right.

(2) *Air transfer elbow*.—Remove, clean, and lubricate. Inspect hose connection to vacuum terminal.

(3) *Universal joint*.—Inspect main unversal joint for lubrication or excessive lubrication, check visually electrical connectors running through universal joint, tighten fuselage and octagon stud bolts if necessary. Clean and lubricate universal stud bolts, bank turner, and pitch action assemblies.

(4) *Turbine and motor unit*.—Inspect brushes and commutator—lubricate if necessary. Check motor mounting bolts and turbine mounting bracket screws. Energize turbine. Check for excessive vibration and heat.

(5) *Collector rings and brushes*.—Check brush assemblies for positive contact through 360° of rotation of the collector ring assembly and for proper alinement of the individual brush wipers with their respective collector ring. Check for loose electrical connections to the brush assembly and collector ring assembly. Clean collector rings.

(6) *Bellows*.—Inspect *thoroughly* the main actuating bellows, regulator bellows and bellows of the pitch action and stall valve assemblies for leaks, loose hose connection elbows, and loose hose connections. Clean and repair if necessary.

INSTRUMENT FLYING TRAINER

WEEKLY INSPECTION SHEET

FOR WEEK OF ______________________ TRAINER NO. ____________

MECHANIC IN CHARGE: ____________ ASSISTANTS: ____________ ____________	SYMBOL COLUMN	REMARKS
1. TURNING MOTOR		
2. AIR TRANSFER ELBOW		
3. UNIVERSAL JOINT		
4. TURBINE & MOTOR UNIT		
5. COLLECTOR RINGS & BRUSHES.		
6. BELLOWS		
7. HOSES & CONNECTIONS		
8. MAIN CONTROL VALVE		
9. CONTROLS		
10. LEVERS & LINKAGES		
11. GYRO FILTERS		
12. FANS & MOTORS		
13. COMPASS DEFLECTOR		
14. RECORDER		
15. WIND DRIFT MECHANISM		
16. POWER PACK & DRY CELLS		
17. SEQUENCE OF INSTR. ADJUSTMENT		
18. REPEAT DAILY INSPECTION		
19. TRANSFERRED TO FORM 47		

FIGURE 170.—Weekly inspection sheet.

(7) *Hose and hose connections.*—Inspect thoroughly all rubber and fabric covered rubber hose and tubing included in the complete vacuum system for deterioration, kinks, chafing, and leaks. Replace if necessary.

(8) *Main control valves.*—Check, clean, and lubricate the faces and spindles of the three main control valves: rudder, aileron, and elevator.

(9) *Controls.*—Check for smoothness of operation and neutralization of the aileron, elevator, rudder, and aileron controls. Clean and lubricate all bearing surfaces.

(10) *Levers and links.*—Inspect, clean, and lubricate all levers and links.

(11) *Gyro filters.*—Remove, clean, or replace the filter paper of the intake filter of the turn and bank indicator and directional gyro.

(12) *Fans and motors.*—Clean and lubricate all fans and fan motors. Check vibrator motors for proper vibration. Clean and lubricate. Check rough air and range keyer motors. Clean and lubricate.

(13) *Compass deflector.*—Check compass deflector switch on rudder valve for time of deflection and positive contact. Check for loose connections of electrical circuit from rudder valve to compass deflector assembly to variable resistor for amount of deflection. Adjust if necessary.

(14) *Recorder.*—Clean and check thoroughly for loose setscrews, synchronization of Teletorque or Autosyn motors, run test track, and adjust if necessary. Check radio compass control for smoothness of operation and correct indications. Clean and lubricate if necessary the Telechron motor collector rings. Check Telechron motor brushes for positive contact with collector rings throughout 360° of rotation. Clean and lubricate Telechron drive wheel spindle. Check and re-ink inking wheel roller if necessary.

(15) *Power packs and dry cells.*—Check output of the power packs and condition of dry cells if used.

(16) *Sequence of adjustments.*—Perform the complete sequence of instrument control adjustments as follows:

(*a*) Check "key" positions. Certain key or basic adjustments are used as a starting point in reregulating the instrument control linkages and levers. It is assumed that the trainer base is level with the fuselage locked level floating. The next step is to determine that the horizontal arms on the pitch action torque rod and on the spin trip assembly are actually horizontal. These should be checked with a small spirit level. Adjust if necessary. Next, check the two

walking beams (pitch action assembly and spin trip assembly) which pivot on the bell cranks of the pitch action shaft and the spin trip assembly shaft. With the rudder pedals neutral, the first one should be vertical; and with the throttle set in "cruising" position, the other walking beam should also be vertical.

NOTE.—It is seldom necessary to readjust these preceding key adjustments.

(*b*) *1.* Check altimeters for proper setting and synchronization.

2. Adjust vertical speed indicator to "0."

(*c*) Perform leak test as follows:

1. Climb trainer to an altitude of at least 1,000 feet.

2. Lock trainer in level position.

3. Set throttle in cruising position, making sure, visually, that both the climb and dive valves are closed. (Arms against the stops.)

4. Secure stall valve pendulum to the front stop (valve closed) with rubber band, wire, or string.

5. Switch off the turbine, leaving main trainer switch on so the vibrators will continue to run, giving more accurate instrument indications.

6. If the system is tight, the altimeter will not show a loss of over 100 feet in 5 minutes. If the leak is greater than 100 feet in 5 minutes, the leak must be discovered and repaired. All tubing and connections in the altitude system must be checked; also the altimeter and vertical speed indicator for cracked glasses, cases, or leaky tubing connections. If the leak is not located in any of the aforementioned places, the climb-dive valves must be checked as previously outlined.

NOTE.—Upon completion of leak test, leave stall valve pendulum tied forward.

(*d*) *Throttle adjustment.*—Adjust throttle so that a rate of climb of from 400 to 500 feet per minute will be indicated on the vertical speed indicator as the trainer passes a simulated altitude of 1,000 feet, as follows: With the trainer running and floating in the lock straps, open the throttle fully and indicate an altitude of 1,000 feet; the vertical speed indicator should show an ascent of approximately 500 feet per minute. This setting is obtained by means of lengthening or shortening the throttle assembly link rod.

(*e*) Check the bleed holes.

(*f*) Check tachometer and airspeed indication for cruising, full throttle, and idling.

(*g*) Untie stall valve pendulum.

(*h*) Check the maximum climb and maximum dive as follows: Unlock trainer with throttle in wide open position, nose trainer up until maximum climb speed is reached (indicator hand in vertical position). In this position the vertical speed indicator should indicate a rate of climb of from 1,200 to 1,300 feet per minute. If it does not, the climb limit valve must be adjusted. Check for maximum descent, placing trainer in level position, altimeter showing an altitude of 1,000 feet. Set the throttle at closed position and nose trainer down to maximum diving position (against stops), and check to see that a rate of descent as shown by the vertical speed indicator is *at least* 800 feet per minute.

(*i*) Adjust stalling speed. Spread between mush and stall.

(*j*) Adjust turn-bank indicator for proper rate.

(*k*) Check and adjust, if necessary, the compass deflector.

(*l*) Check and change, if necessary, the deviation card.

(17) Repeat daily inspection, visual, operating, and flight check.

(18) Clean trainer.

(19) Transcribe to Form No. 47.

55. Monthly inspection.—*a.* As previously outlined, the monthly inspection should be performed on the last working day of each month that coincides with that day of the week reserved for the weekly inspection. This inspection, depending on the number of trained men assigned for the inspection and the various troubles encountered, will, due to its scope, in all probability take longer to complete than the weekly inspection. Accordingly, the entire day on which this inspection is to be performed should be reserved for the monthly inspection. The additional time and effort necessary for this inspection will pay good dividends in time saved on subsequent daily and weekly inspections.

b. The monthly inspection sheet (fig. 171) is afforded as a guide in performing this inspection. In checking, adjusting, and lubricating the various assemblies listed, keep in mind not only the fact that the discrepancies found to exist should be taken care of, but conditions that might lead to discrepancies and malfunctioning of the parts at some future date should be taken into consideration and rectified if possible.

c. It is highly desirable that the complete day be allocated for this inspection, so that ample time for almost any repair found necessary will be available. Do not rush through the inspection, rather be slow, methodical, thorough, and deliberate. Too many minor items that are passed over lightly become items of major importance at a later date and cause undue loss of time, unnecessary expense, and per-

INSTRUMENT FLYING TRAINER—MONTHLY INSPECTION SHEET

MONTH OF ________ TRAINER NO. ________

MECHANIC IN CHARGE ________ ASSISTANTS ________

1. BLEED HOLES		
2. BELLOWS		
3. HOSE CONNECTIONS		
4. LEVERS & LINKAGES		
5. COMPENSATOR SPRINGS		
6. UNIVERSAL STUDS		
7. MAIN CONTROLS		
8. CONTROL VALVES		
9. SLIP STREAM SIMULATORS		
10. BELLOWS HOOK-UP SOCKETS		
11. TURNING MOTOR		
12. BELT & BELT TIGHTENER		
13. TURBINE		
14. AIR TRANSFER ELBOW		
15. UNIVERSAL JOINT		
16. ROUGH AIR MECHANISM		
17. WINGS & FUSELAGE		
18. THROTTLE ASSEMBLY		
19. CLIMB-DIVE VALVES		
20. STALL VALVE		
21. SPIN VALVE		
22. TURN WITH BANK		
23. BANK WITH TURN		
24. NOSE DROP		
25. ALTIMETER		
26. VERTICAL SPEED INDICATOR		
27. AIR SPEED INDICATOR		
28. TACHOMETER		
29. FLIGHT INDICATOR		
30. TURN & BANK INDICATOR		
31. DIRECTIONAL GYRO		
32. MAGNETIC COMPASS		
33. COMPASS DEFLECTOR		
34. CLOCKS		
35. CORDS & PLUGS		
36. COLLECTOR RINGS & BRUSHES		
37. TELEGON SYSTEM		
38. SWITCHES		
39. LIGHTING		
40. FANS & MOTORS		
41. VACUUM TUBES		
42. RADIO RANGE		
43. MARKER BEACONS		
44. COMMUNICATIONS		
45. RADIO COMPASS		
46. RECORDER		
47. WIND DRIFT MECHANISM		
48. LEAK TEST		
49. SEQUENCE OF ADJUSTMENT		
50. FLIGHT CHECK		
51. CLEAN & POLISH		
52. TRANSCRIBED TO FORM 47		
	SYMBOL COLUMN ABOVE	REMARKS ABOVE

FIGURE 171.—Monthly inspection sheet.

haps embarrassment to the person responsible for the proper maintenance of the equipment. *Know what you are doing.* Attempt no repairs, adjustments, or maintenance until all possible aspects are considered and all proper precautions taken to insure the proper procedure. *Know what you are doing.*

56. 500-hour inspection.—*a.* The 500-hour inspection will be performed at the same time as the nearest monthly inspection. For example, if the 500-hour inspection falls due during the last 2 weeks of the month, columns 41, 42, and 43 may be carried on a red dash until the current monthly inspection is performed or if it is quite obvious from the existing total time and the operating schedule that the 500-hour inspection will be due before half of the succeeding month has elapsed, it may be performed with that monthly inspection.

b. This inspection consists of dismantling the turbine if it is considered necessary, thoroughly cleaning all parts, inspecting for worn electrical conductors and excessively worn commutators. If the commutator appears to be worn, have it turned down and undercut before reassembly. Relubricate bearings, reassemble complete turbine, test, and reinstall. The main spring compensator (pitch action assembly) should be removed from the trainer, cleaned and relubricated, reassembled, and installed. All other compensator springs should be checked thoroughly and replaced if necessary. The wings and fuselage should be thoroughly inspected for holes, holes patched, and the complete trainer repainted if necessary. If broken or shorting wires exist in the main spindle and the spare wires included in that assembly have been used, it is advisable to dismount the fuselage and octagon, remove the spindle, disassemble, and rewire; at the same time, checking the main spindle bearings, universal joint bearings, and main air transfer hose.

57. Daily operations record.—The daily operations record (figs. 172 and 173) is not as yet a standard form, but since no standard form exists at present whereby the name of the student or pilot, his problem number, the time spent in this trainer, and other pertinent information for a working day may be recorded temporarily, the daily operations record is offered for this purpose. The following is an explantion of the form in general use at this time:

Heading—Enter numerically the number of the form—No. 1 being the first form for the month, No. 2, the second, etc. Enter the trainer type and number in the spaces provided, for example C-3—4138. Enter the number of the month, day of the month, and year in the spaces provided, as 11-21-41. Enter the name of the organization to

LINK TRAINER
DAILY OPERATION RECORD

FORM________ DATE________

TRAINER: TYPE_____ ORGANIZATION________

TRAINER NO._____ STATION________

NAME RANK	EXERCISE	TIME	GRADE	REMARKS	POSTED INIT.	INSTRUCTOR

TOTAL TIME ________ INSTRUCTOR ________

SEE REVERSE SIDE FOR INFORMATION ON USE OF THIS FORM

FIGURE 172.—Daily operation record.

EACH LESSON CONDUCTED IN THE TRAINER WILL BE ENTERED, SUPPLYING THE TIME IN THE TRAINER IN MINUTES UNDER "TIME"; THE NUMBER OF THE EXERCISE OR PROBLEM AS LISTED BELOW, UNDER "EXERCISE"; AND A, B, OR, C IN ACCORDANCE WITH THE FOLLOWING UNDER "GRADE":

"A." IF PILOT REMAINED WITHIN TOLERANCE LIMITS GIVEN IN THE INSTRUCTORS GUIDE FOR THE PARTICULAR EXERCISE.
"B." IF STUDENT ONLY OCCASIONALLY SLIGHTLY EXCEEDED THE SPECIFIED LIMITS.
"C." IF PILOT DEFINITELY NEEDS MORE PRACTICE ON THE EXERCISE IN QUESTION AS INDICATED BY REPEATEDLY EXCEEDING TOLERANCE LIMITS.

UNDER "REMARKS" NOTE PARTICULAR DIFFICULTIES ENCOUNTERED BY PILOT. UNDER "POSTED" INSERT INSTRUCTORS INITIALS WHEN DATA HAS BEEN POSTED TO THE INDIVIDUAL PROGRESS RECORD.

EACH ENTRY TO BE SIGNED BY THE INSTRUCTOR.

EXERCISE NUMBER 1. FAMILIARIZATION.
" " 2. STRAIGHT COURSE.
" " 3. STRAIGHT FLIGHT.
" " 4. STANDARD RATE TURNS.
" " 5. TURNS TO PREDETERMINED HEADINGS.
" " 6. COORDINATION OF THROTTLE & ELEVATORS.
" " 7. STRAIGHT CLIMBS & GLIDES.
" " 8. CLIMBING & GLIDING TURNS.
" " 9. CLIMBING & GLIDING TURNS TO PREDETERMINED ALTITUDES & HEADINGS.
" " 10. REPEAT NUMBER 6, 7, 8 & 9 WITH "ROUGH AIR".
" " 11. REPEAT NUMBER 8 & 9 AT GLIDING SPEED.
" " 12. 30 10 5 & 2 DEGREE TURNS TO GYRO HEADINGS.
" " 13. USE OF ARTIFICIAL HORIZON.
" " 14. EMERGENCY PULL-UP.
" " 15. STALLS-WITHOUT SPINNING.
" " 16. SPINS.
" " 17. U-TRACK.

RADIO

R1. SIGNAL FAMILIARIZATION.
R2. BEAM INTERCEPTION & BRACKETING-MECHANICAL.
R3. BEAM INTERCEPTION & BRACKETING-ADVANCED.
R4. 90° SYSTEM OF ORIENTATION.
R5. EXISTING MARKER BEACON USES.
R6. TRUE FADE-OUT SYSTEM OF ORIENTATION.
R7. PARALLEL SYSTEM OF ORIENTATION.
R8. FADE-OUT-90° COMBINATION OF ORIENTATION.
R9. PARALLEL-PERPENDICULAR SYSTEM OF ORIENTATION.
R10. LOST-ON-BEAM SYSTEM OF ORIENTATION
R11. MULTI-STATION SYSTEM OF ORIENTATION.
R12. UNKNOWN STATION SYSTEM OF ORIENTATION.
R13. CLOSE-IN PROCEDURE.
R14. RADIO COMPASS-HOMING.
R15. RADIO COMPASS-POSITION FINDING.
R16. LET-DOWN PROCEDURE & HOW TO APPROACH.
R17. INSTRUMENT LANDINGS.
R18. X-COUNTRY.

FIGURE 173.—Daily operation record.

which the trainer is assigned and the station's name in the spaces provided. Enter the name and rank of the student or individual flying the trainer in the column labeled "Name and rank." Enter the exercise number of the problem or problems in the column headed "Exercise." The time the trainer was operated in the performance of the problem in the space provided, the grade (fig. 173), and pertinent remarks and the initials of the person, who at the end of each day transcribes the information from the daily operations sheet to the student's individual progress record. The name of the instructor who supervised the instruction given will be entered in the last column labeled "Instructor." At the end of each day the total time for that day will be computed, placed at the bottom of the page in the space provided, and transcribed to column 2 of Form No. 47. The name of the individual responsible for the transcribing and all instruction given as recorded will sign the bottom of the page. Completed forms may be kept on file at the discretion of the officer in charge.

58. Individual progress record.—*a.* The Individual progress record (fig. 171), is a form designed for the purpose of recording the progress of a student in performing the exercises of the basic and advanced trainer courses and all subsequent refresher time. Entries are transcribed to it and the Air Corps Form No. 1, Flight Report, as explained in detail by Air Corps Circular 15-1, from the daily operations record.

b. The form is very simple and is practically self-explanatory. The space for "Total time" will show the total time for that and all previous sheets, while the "Total sheet time" will show only the time for that sheet.

c. The total sheet time will be divided as to whether it is "instrument" or "radio" time and entered as such. The senior instructor will verify the time and entries and sign his name in the space provided at the bottom of the page.

59. Lubrication.—*a.* Lubrication of the various parts of the complete trainer must be performed regularly, and the proper lubricant must be used in all instances. Generally, if the proper lubricant (see lubrication chart, fig. 175) is not available, the trainer should not be operated until such time as the proper lubricant, or its equivalent, is procured and applied.

b. Too generous an application of a lubricant may cause as much damage, if not more than an improper or too small an application. As a general rule, apply approximately half the amount that you think the unit should have, remembering that oil deteriorates rubber or rubber composition, such as hose and bellows fabrics, and that

INDIVIDUAL PROGRESS RECORD

NAME & RANK ____________________

ORGANIZATION ____________ STATION ____________

DATE	TIME	EXERCISE	GRADE	TRAINER NO.	INSTRUCTOR	REMARKS

INSTRUMENT TIME ________

TOTAL SHEET TIME ________ RADIO TIME ________ INSTRUCTOR ________

TOTAL TIME ________

FIGURE 174.—Individual progress record.

excessive graphite applied to the turning motor may, if the proper precautions are not taken, foul one or all of a number of valves in the instrument control system. Consult the lubrication chart and, if the least in doubt as to the proper procedure for lubrication, consult paragraph in section IV that deals with the part being lubricated.

c. If it is quite apparent that a certain unit is insufficiently lubricated, consult the lubrication chart for the proper lubricant and lubricate, even though the chart does not indicate that lubrication is due. The times for lubrication as specified are the times when the various parts *must* be inspected and lubricated, if the necessity for lubrication has not arisen previous to the specified time. Again the admonishment, *Known what you are doing before proceeding.*

d. Following is a list of the various lubricants, with corresponding Air Corps specifications, to be used as specified by the lubrication chart.

Castor oil	Castor Oil, Spec. 2-8
Instrument oil	Oil, Lubrication, Aircraft Instrument Spec. 2-27
Light oil	Oil, Lubricating, Refrigerating Machine, Grade 10, Spec. VV-O-581
Medium oil	Oil, Lubricating, Class D, SAE 30 (or 40), Spec. VV-O-496
Heavy oil	Oil, Lubricating, Class D, SAE 50, Spec. VV-O-496
Medium grease	Grease, Lubricating, Cup, Medium, Spec. VV-G-681
Shock absorber fluid.	Fluid—Hydraulic Shock Absorber, Edgewater Ring or Equivalent
High melting point grease.	Grease, Lubricating, High Melting Point, Grade 210, Spec. 3560
Graphite	Graphite, Powdered, Aircraft Grade, Spec. 3593

60. Major maintenance.—Routine maintenance very seldom, if ever, necessitates the complete disassembly of the trainer; however, maintenance of major proportions does and will occur which necessitates partial disassembly. An example of such trouble would be the shorting or open circuiting of the electrical conductors extending through the main spindle. The procedure for disassembly, reassembly, and the step by step check after reassembly, are described below in detail.

a. Disassembly.—In the disassembly of the trainer, it is entirely possible to use one of several procedures or routines to remove the

various assemblies and linkages but to facilitate the accomplishment, the following guide outline is offered and will be found practical. Check to see that all switches are to the "off" position and remove the power plug.

LINK TRAINER LUBRICATION CHART

WARNING-EXCESS OIL WILL CAUSE DAMAGE

UNIT	HOURS	PART NAME	NO. PLACE	LUBRICANT
FUSELAGE	AS NEEDED	ARTIFICIAL HORIZON DASH POTS	2	CASTOR OIL
	500	ARTIFICIAL HORIZON	6	INST. OIL
	WEEKLY	CLIMB-DIVE VALVE ASSEMBLY	EXT.	LIGHT OIL
	"	STALL VALVE ASSEMBLIES		" "
	"	VENTILATOR FAN - FRONT	2	" "
	"	SPIN VALVE ASSEMBLY	1	MED. OIL
	"	CLIMB-DIVE COMPENSATOR SPRINGS	2	LIGHT OIL
	"	CONTROL WHEEL REAR BRACKET	1	MED. OIL
	"	CONTROL WHEEL FRONT BRACKET	1	" "
	"	LEVERAGE SYSTEM	23	LIGHT OIL
	"	PITCH ACTION SHAFT BRACKETS	2	" "
	AS NEEDED	SLIPSTREAM SIMULATORS-OLEO-INSIDE	3	S.A. FLUID
	WEEKLY	SLIPSTREAM SIMULATOR FITTINGS	9	LIGHT OIL
	"	CONTROL WHEEL ECCENTRIC BUSHING, GEAR, BALL JOINTS	3	" "
	"	AILERON & RUDDER VALVE COMPENSATOR SPRINGS	2	" "
	"	VIBRATOR MOTORS	2	" "
	"	ROUGH AIR SHAFT, BEARINGS, & CRANK	3	" "
	"	STALL VALVE STOPS & SLIDE HOLE	3	" "
	"	BELLOWS HOOK-UP SOCKETS	4	HEAVY OIL
	"	RUDDER PEDALS	6	MED. OIL
	"	RUDDER BAR - REAR	4	HEAVY OIL
	"	BANK-TURNER, SPIN-TRIP ASSEMBLY	9	MED. OIL
	"	CONTROL STICK, SHAFT, & CONNECTIONS	9	" "
	500	COMPENSATOR SPRINGS	7	LIGHT OIL
	WEEKLY	ROUGH AIR GEARS	1	MED. GREASE
	"	ROUGH AIR MOTOR	1	" "
	"	RUDDER VALVE	1	HEAVY OIL
	"	ELEVATOR VALVE	1	" "
	"	AILERON VALVE	1	" "
CCTAGON	MONTHLY	MAIN UNIVERSAL JOINT	4	MED. GREASE
	"	UNIVERSAL STUDS	2	MED. OIL
	"	TURNING MOTOR GEARS	2	MED. GREASE
	WEEKLY	TURNING MOTOR SLIDE VALVES	10	GRAPHITE
	SEALED	TURNING MOTOR BALL BEARINGS		SEALED
	WEEKLY	BELT TIGHTENER ASSEMBLY	2	HEAVY OIL
BASE	MONTHLY	TURBINE & MOTOR UNIT	2	MED. GREASE-H.M.P.
	"	TRANSFER ELBOW	1	HEAVY OIL
	500	MAIN HOUSING BALL BEARINGS	2	MED. GREASE
	DRY	PICK-UP ASSEMBLY		DRY
EMPENNAGE	MONTHLY	RUDDER & CONTROLS	4	MED. OIL
	"	ELEVATOR CONTROLS	5	" "
WINGS	"	AILERON & CONTROLS	14	" "
	"	AILERON HINGES	4	LIGHT OIL
	"	BELL CRANK POST	2	" "
DESK	WEEKLY	AUTOMATIC RECORDER DRIVE GEARS		" "
	"	RADIO RANGE KEYER	10	" "
	"	VIBRATOR MOTOR	2	" "

FIGURE 175.—Lubrication chart.

(1) *Hood.*—Disconnect all electrical connections and remove the hood. It is plug hinged on the upper right side of the fuselage and cotter pin secured on the rear hinge. Remove the pin and slide the hood to the front.

(2) *Turning motor.*—Remove the turning motor. It is held in place by four screws which fasten it to the vertical turning motor bracket mounts. Remove the belt from the small pulley prior to removing the four holding screws.

(3) *Manifold.*—The air transfer manifold is held in place by hose clamps on the rudder valve and the lower manifold from the center section. Loosen the clamp screws, remove the stall valve hose lead, and lift the manifold out. To remove the lower manifold transfer section, it will be necessary to remove the brace from the floor up to the cross floor backet, loosen the clamp at the fuselage floor, remove the directional gyro vacuum lead, the four small vacuum leads in the left side, and lift the section out.

(4) *Bank turner link rod.*—This unit is fastened to the horizontal arm of the spin trip at the top and into the iron cross of the revolving octagon at the bottom. One nut will free it at the top and the removal of one cotter pin at the bottom will free the link for removal.

(5) *Pitch action spring compensator.*—This rod is held in place by a lock nut at the horizontal arm of the pitch action and is cotter-pin secured at the bottom to the iron cross of the revolving octagon. The removal of the nut and cotter pin make it free for removal.

NOTE.—To facilitate the adjustment of the horizontal arm on the pitch action assembly, the following is recommended. That a locking nut be placed on the lower end of the spring compensator section above the ball socket attachment. With this arrangement it will then be possible to adjust the horizontal arm without removing either end of the assembly and, to secure the adjustment, it is only necessary to retighten the lock nuts against the top and bottom ball socket bodies.

(6) *Hose connections.*—Some of the larger hose are held on by the use of hose clamps; to remove the hose, merely loosen the clamp screw and pull the hose. Other of the smaller hose are held on by their own elasticity and to remove they require only a slight pull. In removing them be careful not to strain the leads. This is applicable especially to the hose leads to bellows.

(7) *Air transfer elbow.*—The air transfer elbow is held in place by a spring harness arrangement. Loosen the single screw in each side of the vertical bracket and remove the assembly. Insert a screw driver in the hose from the elbow to the turbine and pry while applying force to the proper side of the hose and the end of the elbow. The Autosyn motor mount is easily accessible after the air transfer elbow has been removed. The mount is secured by two screws on the main bearing housing, one at the top and one at the bottom. When removed, the entire transmitter assembly will drop down, held only by the

electrical leads. If no work is to be done on the unit proper, there is no further need for disassembly on this section.

(8) *Rudder bar.*—Remove the rudder cable at either end of the rudder bar, disconnect the simulator link rod, the link to the top of the spin trip walking beam, and the three bolts which hold the bar pivot section to the cross floor brace and the entire assembly is free to lift out.

(9) *Climb-dive valve assembly.*—Remove the four wood screws which secure the assembly to the floor of the trainer and disconnect the actuating link rod from the bottom of the pitch action walking beam. Using two wrenches, disconnect lead from the climb valve to the altitule tank and the dive valve to the altimeter tank. This frees the assembly for removal.

(10) *Bellows hook-ups.*—Loosen and remove the locking nut and half round nut from each bellows shaft in the floor of the fuselage. This drops the four main bellows.

(11) *Spin-trip assembly.*—This unit is held to the floor of the fuselage by four wood screws at the corners of the wood base. Remove these screws, disconnect the linkage at the bell crank, and lift the assembly out of the trainer.

(12) *Junction (terminal) blocks.*—These two terminals are each held to the floor of the fuselage by four wood screws. Pull the top half of each block apart from the fixed base, remove the four screws from each base and lay the front block back out of the way. Clip the 110-volt lead to the first and second plug on the rear side of the rear block and the first plug on the front side of the rear block.

(13) *Fuselage.*—The fuselage is held onto the universal by four large stud screws, one just to the front of the center hole, one just to the rear, and one on each side. Remove with a large screw driver. Be sure that the side and rear locking straps are in place prior to the complete removal of these screws. With additional help, lift the entire fuselage, with one man guiding the terminal blocks through the center hole, and set it to one side on some sort of support which will prevent damage to the exposed parts on the under side.

NOTE.—Before removal of the fuselage is effected it is necessary in the case of the C-5 and C-3 trainers to disengage the cables of the hydraulic leveling device from their drums.

(14) *Main universal.*—This joint is held down by four large studs which secure it to the revolving octagon. The removal of the studs frees the unit for removal.

(15) *Revolving octagon.*—This unit is held in place by two large stud type setscrews, one on the top side and one underneath the iron cross.

(16) *Spindle.*—The entire spindle section is held in the center of the iron cross (fixed) by four stud bolts accessible from the top.

(17) *Fixed pulley.*—Secured to the base iron cross by four screws.

(18) *Spindle disassembly.*—To remove the Autosyn gear from the base of the collector ring, remove the four screws from the inner rim of the gear. The collector ring section is held onto the spindle by two screws located above the top ring under the wiring, one on either side. It will be necessary to loosen or cut the wiring (in event of contemplated rewiring only) to remove the collector ring assembly. With the ring assembly off and the wires loose the center hose may be pulled out.

(19) *Stall valve.*—Remove link rod from vertical arm pitch action assembly to stall valve reversing arm. Disconnect lead (tube) to altimeter tank and remove four base screws of stall valve. Remove knurled nut from spring bolt.

(20) *Rudder valve.*—Disconnect linkage to top half of valve, remove the three electrical leads and loosen base of valve by loosening Allen setscrew. It may be necessary to drive the valve out from the under side. If so, use a drift punch and mallet.

(21) *Rough air assembly.*—Remove two long base bolts and the spring holder.

(22) *Elevator valve.*—Remove control column linkage and stud bolt which holds the base into the bracket.

(23) *Spin valve.*—Remove large screw which holds the body of the valve to the base; this affords access to the four base screws.

(24) *Tachometer and air speed bellows.*—Held to side of fuselage by six small wood screws to each assembly.

(25) *Pitch action assembly.*—To remove this entire section, loosen the base screws on the two brackets which mount it to the fuselage floor and disconnect the throttle linkage from the bottom of the walking beam.

(26) *Tachometer reversing arm and bracket.*—Four small wood screws secure this mount to the floor of the fuselage.

(27) *Throttle assembly.*—The quadrant is held to the side of the fuselage by two wood screws. Remove these and the cotter pin which holds the linkage on the pivot and the assembly and linkage is free for removal.

(28) *Stall valve reversing bracket and arm.*—Remove four base screws which secure mount to floor.

(29) *Bell crank, bank with turn.*—Four screws secure this mount to the rear of the brace behind the seat on the right side of the fuselage.

(30) *Main bellows.*—Each of these bellows is fastened to the iron cross of the revolving octagon by four wood screws. In removing, mark each bellows as to its type and position.

(31) *Turbine and motor unit.*—The turbine is held in place by four large wood screws. Remove these and disconnect the leads to the motor from the line-oscillator switch box. (Note the connecting points into the box to facilitate the reconnection.) The turbine can now be removed.

b. Reassembly.—For the purpose of reassembly and the performance of the allied work, the following guide outline is offered.

(1) Set turbine in place and secure.
(2) Replace turning motor belt.
(3) Replace four main bellows on revolving octagon.
(4) Set spindle in place and secure with four studs.
(5) Mount revolving octagon.
(6) Replace hoses and clamps for main valves.
(7) Mount belt tightener assembly on turning motor bracket.
(8) Place universal over air transfer hose and secure in place.
(9) Replace Autosyn transmitter or wind drift unit on base of spindle section.
(10) Air transfer elbow and spring holder.
(11) Set fuselage on universal and secure in place. Four bellows hook-up sockets.

NOTE.—Be sure all wires are pulled through hole in floor and are not clamped between floor and universal.

(12) Pitch action assembly and reversing mechanism for air speed and tachometer.
(13) Replace rod from control column to simulator.
(14) Throttle assembly.
(15) Spin valve. (Disassembly.)
(16) Stall valve.
(17) Pitch action—stall valve reversing link rod and mount.
(18) Rough air simulator assembly.
(19) Aileron valve.
(20) Elevator valve.
(21) Air speed and tachometer bellows.
(22) Spin-trip assembly.
(23) Climb and dive valves.
(24) Resolder three 110-volt leads.
(25) Place and secure junction blocks.
(26) Rudder valve (compass deflector leads).
(27) Spin-trip—rudder—aileron valve linkage.
(28) Bell crank for rudder—aileron valve (bank turn).
(29) Vacuum lead from center section (clamp).

(30) Replace two braces on rudder bar mount.
(31) Rudder bar and linkage.
(32) Manifold.
(33) Hose and clamps on main valves.
(34) Check all connections and replace all small hose.
(35) Replace turning motor and set belt on pulley.
(36) Set in place and connect pitch action spring compensator section and bank-turn link rod.
(37) Make general inspection to be sure all linkage is in place and secured and that all hose and leads are in place and secure.
(38) Replace gyro filters.
(39) Check oscillator section for general operation.
(40) Perform logical sequence of adjustments.
(41) Flight check.

c. Check list.—The following check list and checking information is afforded for use during the foregoing procedure:

(1) *Brackets, screws, and bolts.*—With the trainer disassembled and all parts removed, a complete check should be made of the fuselage, octagons, and base. All dirt and grease should be removed. Check and if necessary retighten all screws, stud bolts, and nuts. Replace any which cannot be tightened because of improper size, stripped threads, or enlarged holes.

(2) *Clean, lubricate, and check action.*—All parts, while out of the trainer, are to be checked closely. Clean each piece and, in event of moving parts, relubricate. Remove any excess or lost motion and in the case of ball-socket joints, check for and remove any end play. Check all valves and moving parts for proper freedom of action.

(3) *Bellows.*—Examine all bellows. Look for and repair any leaks. As a possible source of future trouble, note any slightly frayed or cracked points in the fabric. Those which warrant it should be patched. Check alinement of scissors on main bellows.

(4) *Universal.*—Check the main universal joint to see if it has a smooth inside finish. If not, dismantle and with a file remove all rough edges and burs. Check the under side of the top plate and if the travel of the joint has caused the plate to rest on the rounded section where the joint is pinned together, round off the corners to prevent riveting of the stud heads which hold the fuselage on the universal.

(5) *Spindle wiring.*—Check the wiring on the spindle, if worn or frayed, rewire the entire assembly. If blueprints are unavailable on the procedure, take the measurements of the spiral section, noting the

taped, clear, and seized portions in order to be able to rewire in proper manner.

(6) *Collector rings.*—Check the collector rings for dents, abrasions, or rough spots. If necessary use crocus cloth to polish the surfaces to insure smooth and continued contact.

(7) *Linkage.*—In the reassembly, all adjustable linkage will be loose and no adjustments should be attempted until the reassembly is complete and the logical sequence of adjustments is started.

(8) *Spindle Autosyn gear.*—The gear on the base of the rotating spindle, which meshes with the Autosyn gear, is held in place by four stud bolt type screws. Be sure to check before replacing them, that the short and long screws go into the proper holes and that the assembly is held well up in place as it should be. Failure to do so will make it impossible to get the gears in mesh.

(9) *Spin valve.*—In replacing the spin valve, remember that the body of the valve must be removed from the base in order to insert the base screws.

(10) *Leads; care in handling.*—In working with the climb-dive valve assembly and stall valve assembly, take care not to endanger the vacuum leads of the valves. They are soldered in place, and if broken loose, must be resoldered with a torch. The leads into the main bellows, spin-trip, stall valve bellows, air speed and tachometer bellows, and turn-bank regulator bellows are merely glued into place, metal to wood, and break loose rather easily. They should be handled accordingly.

(11) *Hose, reconnecting.*—To prevent a loss and waste of time, the hose leads to the main valves, bellows, and turning motor should be marked upon removal so as to be replaced properly. This holds true also of the leads to the spin-trip and spin valve, as well as the bases which make up the nose drop feature. Improper reactions will be encountered if these leads are in any way interchanged from normal. Exercise the same precaution on the rough air leads and hose.

(12) *Hook-up sockets.*—In putting the main bellows back and hooking them up, the bellows hook-up socket should be adjusted into the half round nut in the floor of the fuselage to give approximately ¼ inch play with the bellows fully expanded, not under pressure, and the trainer banked to the limits away from the bellows being adjusted. After being properly adjusted, the locking nut is to be placed on and securely tightened. Be sure the half round nut does not turn when locking the two or the adjustment must be repeated. If the adjustment is made as it should be and the locking nut secured,

the adjustment will remain for as long as needed, otherwise, after a few running hours, the performance will again be necessary.

(13) *Junction blocks.*—The terminal blocks in the floor of the fuselage are fastened down by four wood screws each and the blocks are in two parts, the upper and lower sections. In disassembly they must be pulled apart and the lower sections removed from the floor. There are three 110-volt leads connected to the rear block and these leads must be removed for disassembly. They can be cut close to the point at which they are soldered. The green wire fastens to the second plug from the near end on the rear side, the black wire to the first plug on the same side, and the grey wire to the first plug on the front side of the same block.

(14) *Rudder valve, isolated.*—When replacing the rudder valve do not forget the compass deflector leads, and when putting the manifold hose on, be absolutely sure that the manifold is in no way touching any portion of the rudder valve. If a continuous circuit is made through such an adjustment, a number of circuits will be completed which are isolated with the manifold set in properly, and improper operation of the radio circuits will be noticed.

(15) *Autosyn assembly and collector rings.*—In remounting the Autosyn transmitter assembly on the base of the main bearing housing, the small stud bolt goes into the lower part of the bracket, and the large one in the upper hold. Before tightening these two studs, make sure that the brushes are making firm and continuous contact with the collector rings. If the contact is not continuous the circuit which is completed through that particular ring and brush will be intermittent and the trainer will not function properly. The same general conditions will set themselves up if the brushes and/or rings are allowed to become dirty or corroded.

(16) *Ball-socket joints and adjustments.*—In making the adjustments on the linkage which has the ball socket joints, it is strongly recommended that the adjustments be made by turning the entire unit rather than removing the ball from the socket. If the ball and socket adjustment is disturbed it is almost a necessity to remove the entire linkage to readjust the set stud, which is cotter-pin secured, to remove the play and get the proper amount of action without having too much freedom or too much bind. If it is necesary to remove the end section, make sure that a wide blade screw driver is used or it is almost certain that the set stud will be ruined.

(17) *Filters on gyro instruments.*—Remove and clean or replace gyro filters. Clean bleed holes and check all electrical leads and units.

SECTION VI

INSTALLATION

61. General.—Information contained in this section is included as a general guide for the installation of new units as they are received from the manufacturer and is written around the type C–3 trainer now being delivered; however, the same procedure is applicable, except in minor details, to the installation of all types now in use.

62. Selection of trainer room.—*a.* Care in the selection of the trainer room can often materially improve the efficiency of operation and reduce the work of installation. Unless a large freight elevator is available, a room on the ground floor is preferable. Otherwise, it might be necessary to dismantle the trainer and move it in sections.

b. While the trainer may be operated in a room as small as 14 by 19 feet, it is preferable that the space be not less than 22 feet 6 inches by 17 feet 6 inches (fig. 176). The added space will be found to be very useful. The room must be heated to normal room temperature and must be reasonably free of dust; for example, if the room is adjacent to a dirty airport or runway, open windows should be equipped with one of the various air cleaners available. Care in this respect will pay dividends in the form of longer operating life and more trouble-free operation. It should be borne in mind that the trainer is vacuum-operated and that eventually all the air in the room, and any floating dust particles, will circulate through the valves and bellows. This could clog needle and regulating valves and would be almost sure to cause undue wear of all moving parts. For most efficient operation, the room should be well lighted and ventilated.

c. Since many of the problems and exercises worked by students in the trainer involve the use of the magnetic compass, it is desirable that the trainer room be located as far as possible from large transformers and other heavy-duty electrical apparatus, and away from large movable masses of metal such as aircraft engines. Such interference causes the compress indications to vary from day to day and renders it impossible to utilize an accurate deviation card.

d. The minimum door size through which the trainer will pass without dismantling is 37 inches. Minimum ceiling height necessary is 9 feet 7 inches.

e. While not essential, it is desirable to select a room which runs north and south. This makes it possible to locate the trainer so that, with the map right side up on the desk, north on the map coincides

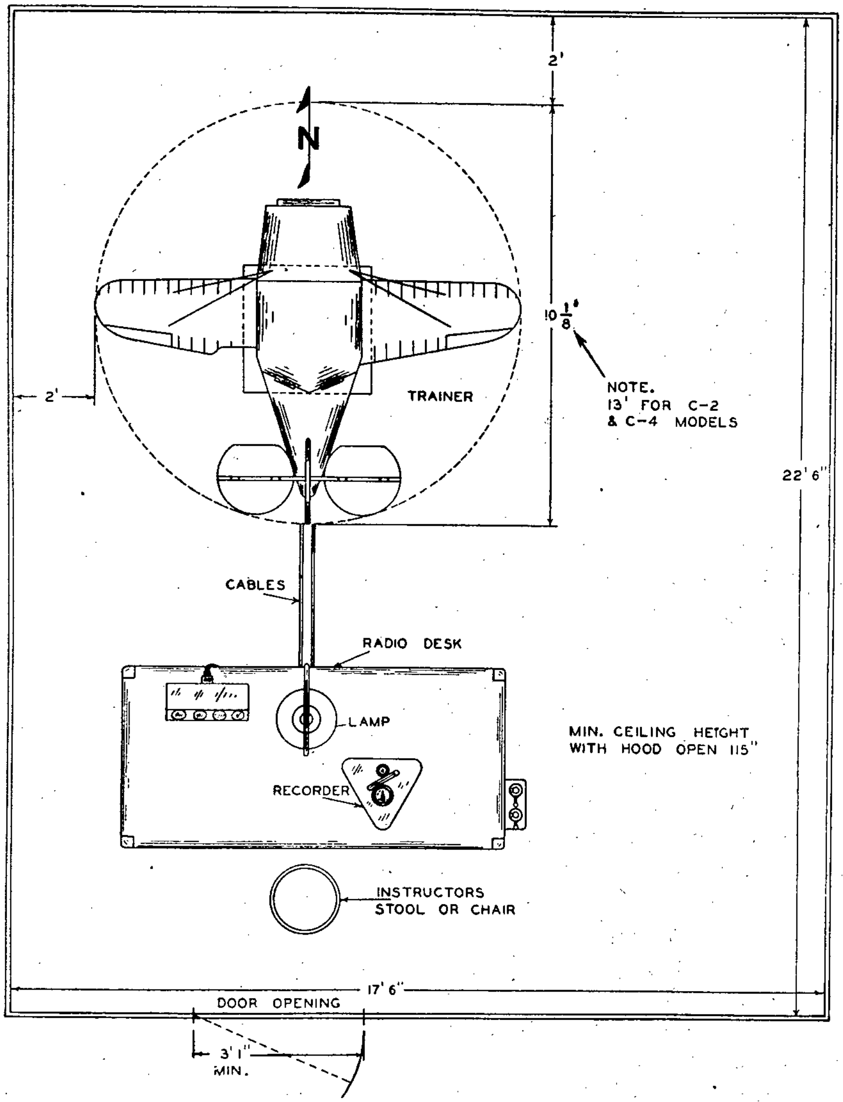


FIGURE 176.—Trainer location and room size.

with north on the trainer compass. Other furniture and equipment needed to make the installation complete includes a filing cabinet, the type used for storing blueprints, for storing maps and tracings; a storage cabinet for books, spare instruments, etc., and extra chairs and

headphones so that additional students may sit around the desk, listen in, and observe operations.

63. Unpacking trainer.—A certain routine order is followed at the factory in packing the trainer for shipment. Unpacking is a simple job if the reverse of this order is known and followed. It is recommended that the following directions be *carefully adhered to*. Otherwise, considerable damage may result.

a. The box containing the trainer should be moved as near as possible to the site selected for the trainer room, in order that the trainer be moved as little as possible after removal from the box.

b. Remove the side of the box marked "Remove this side first" by extracting the nails all the way around this side. If there is room enough, the bottom row of nails may be left in and broken loose by pulling the side of the box down.

c. Remove the other side of the box in the same manner.

d. With the sides of the box removed, the wings will be found standing on end against the sides of the rear end of the fuselage. The root fittings of each wing are attached to a small piece of board which is part of the crate. Unscrew these small boards and remove the wings.

e. Remove the packages attached to the front end of the box.

Caution: *Do not yet attempt to remove the cockpit hood* (the large package under the nose of the fuselage).

f. Remove all nails from the *bottom* of the end sections of the box.

g. Remove all nails that are driven down through the top of the case into the five 2- by 4-inch uprights.

h. The ends and top of the box may now be lifted and carried sideways away from the trainer.

i. Remove the desk, being careful to turn it completely right side up before resting any of its weight on the legs.

j. Remove all small boxes of accessories.

k. Remove cockpit hood.

l. Remove paper wrapping from turning motor, which was under the cockpit hood. To avoid damage to the turning motor, its metal cover should be located immediately and put in place.

m. Remove the 2 by 4 upright at the rear of the fuselage.

n. Engage side locking strap on left side of trainer; then remove the two 2 by 4 uprights that form the cradle that supports the *rear* of the fuselage.

Caution: In removing this cradle, be sure that the icing valve, a small valve located under the right hand rear longeron, is not damaged.

o. Remove the front cradle. Nose the trainer down slightly and this cradle will slip over the nose. Then engage the rear locking strap located under the rear of the fuselage.

p. Remove all four panels from the base of the trainer.

q. Four lag screws which secure the trainer to the bottom of the box must be removed. These are located near the corners of the trainer base and extend down through the metal corner braces of the base.

r. Remove any further boxes found stored in the base except the one with wires connecting it to the brushes on the collector ring assembly.

s. Slide trainer off the floor of the box to the part of the room where it is to be set permanently.

t. Remove the two wooden blocks under the turning motor supporting arms.

u. Remove four lag screws that extend up through the top of the trainer base into tapered wooden blocks between the base and revolving octagon, and remove the blocks. These blocks can easily be loosened by turning the trainer a quarter turn to the left.

v. Check the brushes in the base of the trainer to be sure they are riding the slip rings and have not fallen between the rings.

64. Assembly and installation.—The trainer should be unpacked in the room it is to occupy and the crating materials cleared away.

a. General.—(1) Move the trainer to its final location (preferably the north end of the room).

(2) Rotate the fuselage slowly one complete turn to be sure it turns freely.

(3) Head the trainer north by its own compass and turn, or slide, the base around until the switch box in the base faces the general direction of where the trainer desk will be installed. Square up the base with the fuselage, with the compass still on North. (No outside compass or exact magnetic north line is needed.)

(4) Attach left wing first and adjust the wing struts until the door fits properly.

(5) Attach right wing and adjust struts until right wing tip is same height above floor as left wing tip.

(6) Attach tail surfaces and hook up. Struts and rods are tagged.

(7) Attach cockpit hood and, for safety, cotter pin immediately.

b. Desk lamp bracket and recorder cable supporter.—The desk lamp bracket contains the wiring for the desk light and the 12-wire recorder cable. After attaching the lamp bracket to the desk, it will

be necessary to attach the wire ends to the correct terminals in the junction box under the desk.

c. In fuselage.—(1) *General.*—Remove the two wooden blocks screwed to fuselage to hold seat during shipment, and remove seat. The seat removes easily if lifted straight up until it clears the door sill.

(*a*) Remove safety wire from the inverted valve pendulums.

(*b*) The control wheel or stick is prevented from moving in shipment by closing the slipstream simulator needle valve. This valve should be opened slightly before attempting to move the elevators.

(*c*) Replace seat.

(*d*) Remove artificial horizon. Remove locking screws and fill dash pots.

(2) *Compensate compass.*—(*a*) Head trainer north by its own compass, and see that the square trainer base lines up with the fuselage. This should be checked carefully so that the base may be used as a "compass rose", to "swing ship" on the cardinal points. This alinement can be checked by sighting down past the side of the fuselage, seeing that it parallels the base. No other compass or north-south line is necessary.

(*b*) After the base is squared up with North as indicated by the trainer compass, turn the fuselage 90° to the right and *line up the side of the fuselage* with the base. Using the E–W compensator screw, adjust the compass to read exactly East.

(*c*) Next, have an assistant turn the trainer another 90° to the right and line it up again with the base. The compass should now read South but if there is any ironwork in the building, or other magnetic interference, an error will be present. Using the N–S compensating screw, reduce the error by one half its amount. This will divide the error between northerly and southerly headings.

(*d*) Next, turn the trainer to a westerly heading and line it up with the base. If the compass does not show exactly West, split the error as was done on the south heading.

(3) *Deviation card.*—(*a*) While making out the deviation card, the hood should be closed and the trainer running, but with the locking straps left on.

(*b*) The rudder must be in neutral to prevent the compass deflector (which simulates northerly turning error), from operating. It is essential to have an asistant stand outside the trainer and swing it to the desired headings and hold it steady while the compass settles down.

(*c*) Have the assistant head the trainer north and *line it up with the base.* Set the directional gyro to exactly zero. After the compass has settled down, note down its heading.

(*d*) Have assistant turn the trainer to a gyro heading of 30°, wait for the compass to settle and note down its heading.

(*e*) Turn to a gyro heading of 60° and repeat the process.

(*f*) Turn to an easterly heading and *line up with the base.* Note down compass heading as before, and check gyro for a heading of exactly 90°, resetting the gyro if necessary.

(*g*) Continue all the way around the compass in 30° intervals as above.

(*h*) If another assistant is available, time can be saved by attaching the heading indicating pointers to the octagon, while the deviation card is being made. These cards should be put on at 30° intervals, to show *magnetic* heading rather than *compass* heading, thus affording information to the instructor as to whether the student is correcting for deviation. The heading indicating pointers should be exactly 30° apart, by the directional gyro.

d. Leveling trainer.—(1) In order that the instruments function properly, the trainer should be carefully leveled. Four jackscrews are provided on the corners of the base for this purpose.

(2) A carpenter's level should be laid on the edge of the revolving octagon and the trainer should be turned until the level approximately parallels one diagonal of the square base. Note the position of the bubble in the level and rotate the trainer 180°. If the trainer is level, the bubble will still be in the same spot, even though not in the exact center of the glass. If the bubble changed position, raise the low corner of the trainer indicated by the level, by screwing down on the leveling screw on the low corner as necessary. When the trainer is level in the direction first attacked, turn to a heading 90° from it and level the trainer in that direction. When the trainer is properly leveled, the bubble in the spirit level will not change position while the fuselage is turned through 360°.

e. Connection to power supply.—Connect a No. 14 two-conductor BX cable to the nearest supply line, fused for 20 amperes. The BX cable should be led under one side of the trainer base and connected to the function box through a fitting provided there. The two wires of the cable should be connected to L1 and L2 in junction box. It will not be necessary to consider any polarity.

f. Connecting desk and wind drift mechanism.—(1) It is desirable to place the desk at the south end of the trainer room. The instructor may then look directly over it at the trainer and at the same time,

his maps—right side up on his desk with North away from him—will agree with the trainer compass. If the above is not possible due to the lay-out of the room, additional instructions appear later where needed.

(2) With the desk in place, uncoil the cables and straighten them out on the floor. The desk lamp bracket contains the wiring for the desk light and the 12-wire recorder cable. After attaching the lamp bracket to the desk, it will be necessary to attach the wire ends to correct terminals in the junction box under the desk. The remaining large, long cable connects the desk with the junction box in the trainer base. Two opposite sides of the base have a space between the bottom of the base and the floor of the room. The 33-point plug on the end of the large cable is pushed under the base and plugged into receptacle located in the back of the upper left-hand corner of junction box. (It may be necessary to raise the base slightly to place the plug underneath.) Uncoil both the flexible metal cables and straighten them out.

(3) It will be noted by reference to figure 177, that two standard installations are provided, choice of either being dependent on the size of the room. All trainers are provided with desk to trainer connecting cables long enough to provide 8 feet between base and desk. If the room is small, the above distance may be shortened to 5 feet. In this case, the wire cable for the wind drift mechanism must be curved as shown in figure 177. These cables should then have all the kinks removed and should be installed from desk to base as in figure 177. With wind velocity dial at desk set to zero, connect one end of one flexible cable to it and the other end of the cable to outlet (A) (fig. 120) at the end of wind drift case. Set the wind direction dial at desk to zero and connect the other flexible cable to it and to outlet (B) (fig. 120), in the middle of wind drift case. An 8-foot metal cover is supplied to protect the cables between the desk and the trainer. If the 5-foot distance is used, the cover must be cut to the 5-foot length.

(4) Remove the flight log (automatic recorder) from the lower right-hand desk drawer. Attach driving motors, being careful that the vertical shaft is properly bedded down in the milled channel in the mounting plate. It is possible to install these motors on the wrong side of the vertical spindles. Such an error will crush and damage the brushes. Therefore, care should be taken to be sure the brushes just nicely reach and press against the rings before tightening the slotted nut. Set the recorder gently on the desk and plug in the short 10-wire cable which comes out of the lamp support over the desk. Crank the wind velocity dial and wind direction dial at the desk to zero.

(5) In normal operation, it is customary to place the map or chart on the desk with north away from the instructor. The flight log should be placed on the chart so that the driving wheels are located east and west of each other, that is, magnetic east and west, as shown on the map. It is not necessary to line up map and recorder with reference to the magnetic compass as this relationship was taken care of in synchronizing the recorder. It is then only necessary to rotate by

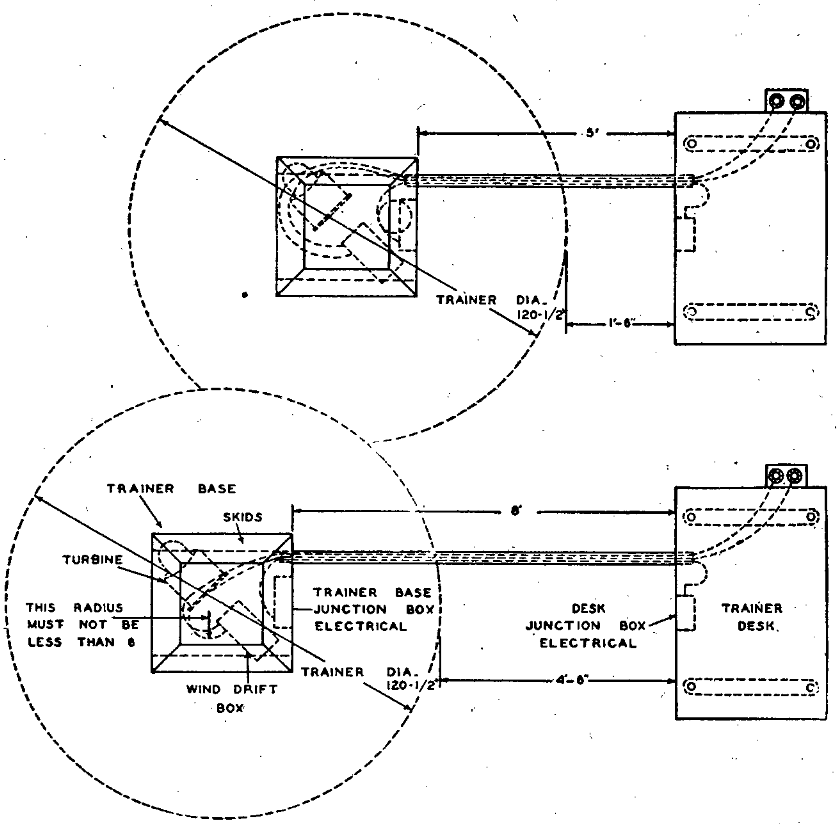


FIGURE 177.—Installation of C-3 and C-5 trainers.

hand the large gears on the recorder until the inking wheel is pointed in the same direction *on the map* as the trainer is *headed by its own compass*, as shown by the *markers* on the revolving octagon. If the trainer room does not lie north and south as recommended in section 1, an extra adjustment must be made. Head the trainer north by its own compass and turn base around until the base junction box faces the general direction in which the desk is installed. Proceed to compensate the compass as previously described.

(6) In the base, spring out pick-up assembly bracket so that the gears just clear each other. Slowly rotate trainer until it is headed north by its own compass and fuselage square with the base. Allow gears to engage. The wind drift unit in the base is now set to zero wind direction and zero wind velocity with the trainer headed north.

g. Installation of radio and desk light.—(1) The radio equipment involves one assembly which is installed in the middle drawer of the radio desk. This unit is provided with one simple plug-in connector connecting the radio and desk terminal in the back of the desk.

(2) Place the radio chassis in the middle drawer and connect large plug-in connector to the back of the radio chassis.

NOTE.—Before connecting any plugs or cables, be sure that all switches are turned to the off position.

(3) Next, install the tubes if they are packed separately. The tubes must be installed in their proper sockets. The instructor's earphones and microphone plug into jacks located on the right hand corner of the radio chassis. Additional jacks are located around the outside of the desk so that several additional pairs of phones may be plugged in. ***Caution:*** If these headphones are replaced or additional pairs are used, they must be of 2,000 ohms impedance.

h. Desk lighting fixture.—The fixture which supports the lamp over the trainer desk, and which also carries the recorder cable, should next be bolted to the back of the instructor's desk in the position shown in the frontispiece. The recorder cable was merely pulled through this fixture sufficient to allow slack for packing purposes, but was not disconnected from the terminal box. In addition to this recorder cable, there are two wires which supply 110-volt current to the lamp. These wires were disconnected for packing and must be reconnected to terminals 1 and 2 on the desk terminal block in the junction box located in the back of the desk. Since this is alternating current, it does not matter which wire goes on which of the two 110-volt terminals.

65. General operating instructions.—*a.* See that all cables are plugged in properly. Turn on the line switch located on the front of the base junction box marked "Line." Turn on the oscillator switch, located on the front of the base junction box, and wait about 30 seconds for the oscillator to warm up and the remote indicating instrument to "come alive." See that the altimeter on the desk agrees exactly with the one in the trainer.

b. Set the altimeters approximately 500 feet below zero. (This is because the last 500 feet of altitude decreases slowly, due to the pressure in the altitude tank being so close to the atmospheric pressure in the

room. This is no disadvantage as problems are considered to start or end when the altimeter reaches zero.

c. The trainer is turned on by means of the ignition switch located on the right-hand side of the instrument panel in the trainer cockpit. Instructions for unlocking and relocking the fuselage with a student in the trainer areas follows:

(1) *Unlocking the trainer.*—With the student seated in the trainer, warn him not to turn the switch "on" or "off" until asked to do so. The instructor will handle the controls while unlocking or locking the trainer straps. With the student seated in the trainer, turn on the main switch and "flip" the spin valve in the reverse direction by hand, thus tending to stop the trainer from spinning. Grasp the controls with the left hand and move the stick or wheel forward and back to "float" the trainer in the rear lock strap. Unhook the rear strap and lay it in a horizontal position against the stop. Place the left hand on the side lock strap and the right hand on the stick or wheel and move to "float" the trainer in the side strap. Remove the side strap and place it in a horizontal position against the stop. The "take off" is made without any loss of control on the part of either the student or the instructor.

(2) *Relocking the trainer.*—Be sure the rough air is turned off. Secure the side lock strap first while steadying the trainer with the right hand on the stick or wheel. The rear lock strap may be maneuvered into position by using the left hand on the control stick or wheel, juggling it to engage the rear lock strap with the right hand. As soon as the trainer is locked in position ask for "switch off" of the ignition.

d. By means of a key, which will be found suspended from the directional gyro caging knob on new trainers, wind up the fuel gage to the desired "gallons".

NOTE.—With the fuel switch "on" the trainer will not run unless the gage indicates a supply of fuel. With this switch "off" the fuel gage has no effect on the operation.

e. Before putting the trainer in operation, the side and rear locking strap should be slipped off the locking pin and laid against the hook provided for the purpose. To completely release the fuselage for operation, merely turn slightly to the left the valve knob located at the bottom, on the forward side of the leveling jack on the cockpit floor. With the recorder on the desk and connected, spin the large gears by hand until the inking wheel is traveling the same direction on the map that the trainer is headed by its compass. When ready to actually start a problem, turn on the on-off switch located on top

of the recorder. A "rough air" mechanism is provided to simulate stormy conditions. This is located near the right rear longeron and is put in operation by screwing in on the small crank. This crank may be partially screwed in to provide varying degrees of rough air. Also located on the rear right longeron is the "icing valve". When this valve is closed, air is shut off from the air speed indicator system, simulating icing conditions. For normal operation, this valve must be opened.

f. To relevel and lock the fuselage after a problem is completed, simply close the valve on the bottom of the leveling jack and pump the handle until it feels solid.

NOTE.—Do not force the leveling jack to overcome the operating pull of the main bellows; fly the trainer to a level position.

g. Operation of the controls and the use of the instruments is the same as in an airplane. It will be noted, however, that the trainer has no stability and no particular feel. It is purposely built this way so that the student will be forced to fly entirely by instrument. It has been found that when a student learns to fly instruments under "no feel" conditions, later on it matters very little to him what type of airplane he flies.

h. Spins are accomplished, purposely or accidentally, by nosing up until air speed falls below the stalling speed. Recovery is made as in an airplane, by nosing down and applying opposite rudder. It will be noted that the trainer "spins" with the nose high, instead of nose down as in an airplane. This is not important, however, as the proper instrument indications are shown, and the student under the hood cannot see the attitude and must recover by instrument.

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